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PROGRESS REPORT

OF THE

TRANSPORTATION AND FACILITIES RESEARCH DIVISION

MARKETING & NUTRITION RESEARCH

July 1, 1970

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Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

This progress report includes a summary of the current research of the Division and a preliminary report of progress made during the preceding year. The summaries of progress include some tentative results that have not been tested sufficiently to justify general release. Because of this, the report is not intended for publication. Copies are distributed only to members of the Division staff and others having a special interest in the Division's research programs.

The report was compiled in the Transportation and Facilities Research Division, Agricultural Research Service, U.S. Department of Agriculture, Federal Center Building, Hyattsville, Maryland.

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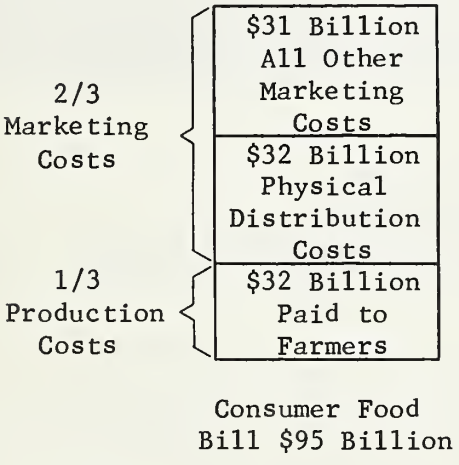
Issued October 1970

PROGRESS REPORT OF THE TRANSPORTATION AND FACILITIES RESEARCH DIVISION
MARKETING AND NUTRITION RESEARCH

July 1, 1970

INTRODUCTION

Transportation and marketing facilities research of ARS is concerned with the structures, equipment, containers, devices, work methods, and operating procedures used in the physical distribution of farm and food products from the farms to consumers. It seeks to find ways to improve these physical elements and handling methods in order to increase their efficiency and effectiveness in performing the numerous operations involved, increase labor productivity, and help hold down marketing costs. The functions to which these physical elements relate are assembling, preparing for market, processing, packaging, precooling, loading, transporting, unloading, storing, warehousing, and wholesale and retail distribution.

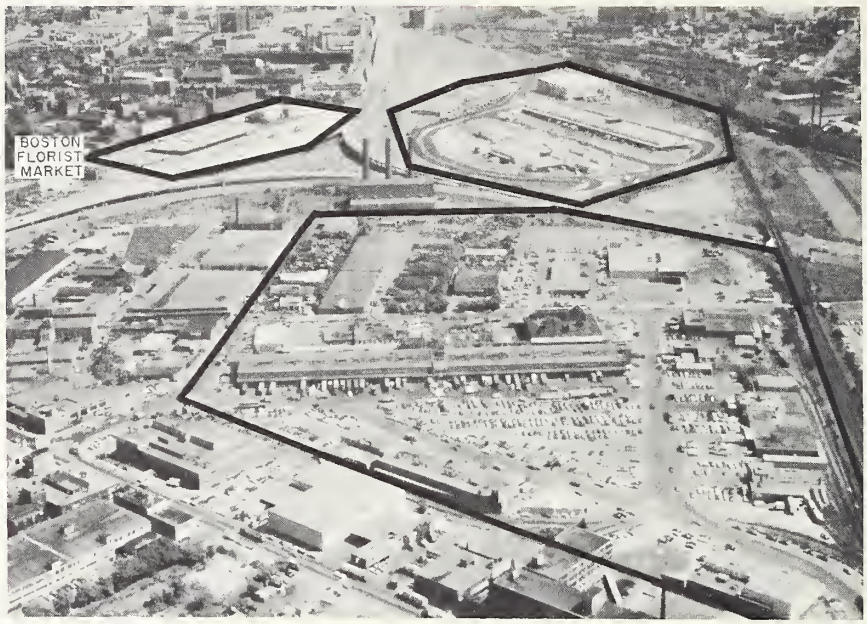


Our system of producing and distributing food is supplying the consumers $95.3 billion worth of food annually. In 1969, it cost $32.1 billion for growing the food and $63.2 billion for marketing it. The cost of physically handling food during the marketing process requires about one-half of the total marketing costs or the same as the cost of growing it. It is this half of the total food-marketing bill that is directly affected by research in the areas covered by this report. In 1969, the hourly wages of employees in food-marketing establishments were $2.89 compared to $2.67 for the previous year. Prices of other goods and services utilized by food marketing firms also were higher this past year than in the preceding year.

The research done during the past 20 years to make marketing more efficient is paying off. Labor cost per unit marketed has gone up only about one-third as much as wage rates of labor engaged in these activities. If the full increase in the cost of labor during the past 20 years had been reflected in higher marketing costs, the total annual food marketing bill now would be about $14 billion greater than it is.

Most of the research by industry differs substantially from that done by public agencies. It relates primarily to the development of products or services which the individual firms offer for sale and is profit oriented. Some of the research and developmental work of industry involves adaptation of research findings of public agencies. Most of the research findings are trade secrets and therefore not made public. Thus, research contributions to public knowledge in this field must come mainly from public-supported research. Such research has special significance to the small firms that cannot afford to do their own research.

NEW FACILITIES COSTING MORE THAN $50 MILLION HAVE BEEN BUILT IN BOSTON AS A RESULT OF THE DIVISION'S PLANNING STUDIES



NEW BOSTON MEAT MARKET

NEW WHOLESALE FOOD MARKETS OPENED IN BOSTON...

NEW PRODUCE & GROCERY FACILITIES

THESE NEW FACILITIES SHOULD RESULT IN ANNUAL SAVINGS OF $5 MILLION IN FOOD HANDLING COSTS

Industry contributes to the Division's research in numerous ways, particularly in permitting the free use of its facilities, equipment, materials, and supplies in research experiments and tests. Also, in some cases, industry groups have made cash contributions to help finance our research in this field. Research by the Division frequently serves as a catalyst or stimulus to industry research. Indicative of the research results being obtained and the extent of their application by industry are the following examples:

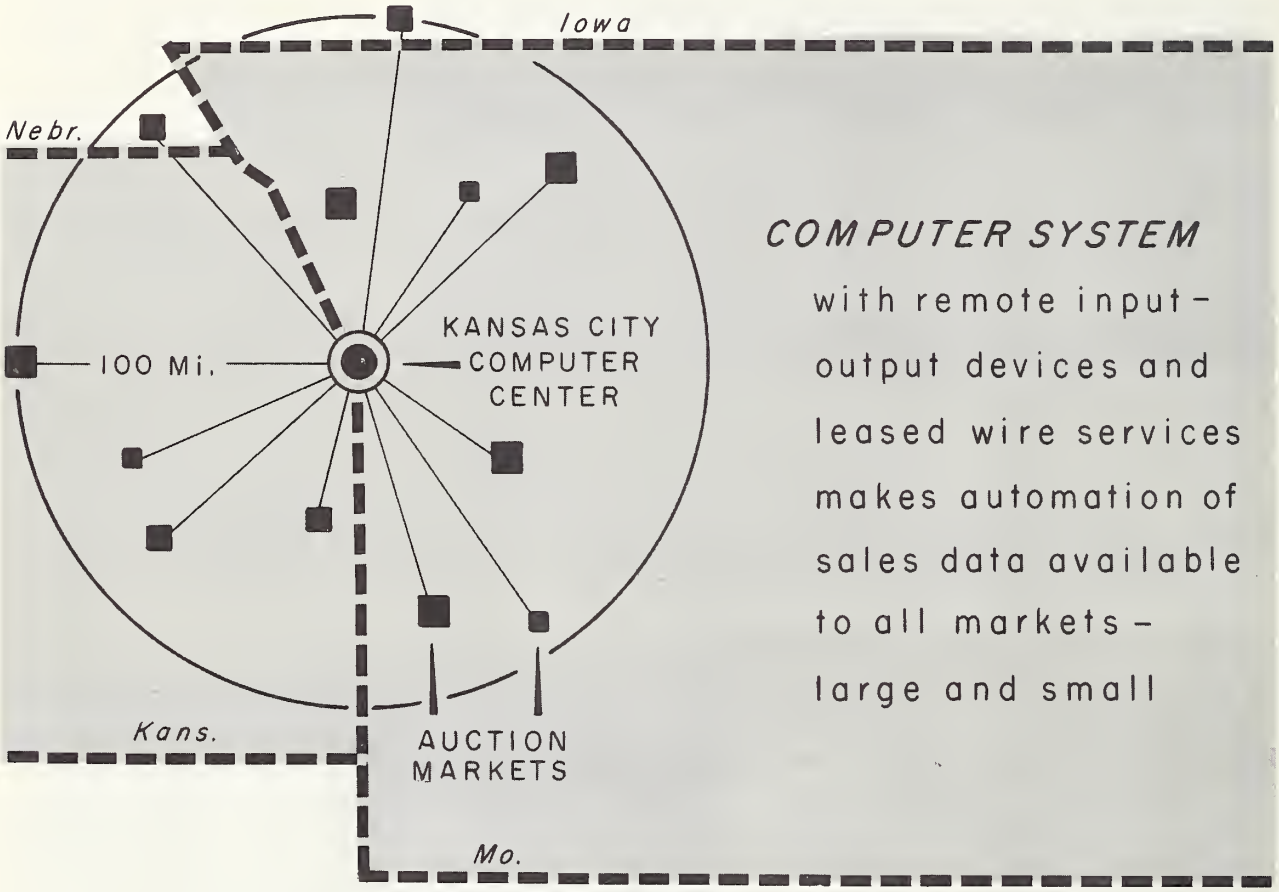
Marketing Facilities in Cities

Dedication of the new wholesale meat distribution facilities in Boston marks the completion by the food industry of the modernization of the city's food distribution facilities at a cost of more than $50 million. Altogether, these facilities will save an estimated $5 million each year in food handling costs. In New York leases have been signed for more than $58 million worth of additional facilities to be built by the city in the new Hunts Point Food Distribution Center. For Los Angeles, a tentative master plan has been developed for a new 500-acre wholesale food distribution center which provides over 2 million square feet of first floor space in more than 50 buildings for 250 distributors of all kinds of food. The construction of the first phase of a 3-million-cubic-foot cold storage warehouse has been completed at the new Western Food Center in Denver. Plans were developed for an $8.7 million food distribution center on a 70-acre site in Minneapolis. New facilities costing over $2 million were added at the Genesee Valley Regional Market in Rochester, N. Y. The $100-million wholesale food distribution center in Philadelphia has achieved its development goal 5 years ahead of its 1974 target date, with all but 2 of the 388 acres now taken.

Marketing Facilities in Producing Areas

In cooperation with State agencies, food industries, and farm groups, plans were developed for 12 producing area marketing facilities in nine States. A study has been initiated for a proposed marketing organization and facility for apples in the "Four Corners" area of New Mexico, Arizona, Colorado, and Utah. A major part of the egg products in northeast Alabama will be processed in new facilities for which plans have been developed in cooperation with the Alabama Department of Agriculture and Industries. Improved poultry processing and distribution facilities planned in Kansas will serve as guides for small poultry processors in the State who must meet the requirements of the Wholesome Poultry Act. Plans were developed for a facility at Greeley, Colo., to house both milking and milk processing operations. This facility, a part of which is already built, makes it possible for the same amount of labor to handle a 50-percent greater volume of products.

COMPUTER SYSTEM FOR PROCESSING SALES DATA ON LIVESTOCK AUCTION MARKETS



COMPUTER SYSTEM

with remote input – output devices and leased wire services makes automation of sales data available to all markets – large and small

ADVANTAGES

- MINIMIZES ERRORS IN COMPUTATIONS
- REDUCES INCIDENCE OF MISCOUNTS AND LOST ANIMALS
- SPEEDS UP PAYMENT FOR ANIMALS FOLLOWING SALE
- PROVIDES PERMANENT RECORDS OF SALES TRANSACTIONS
- ADOPTION COULD REDUCE CLERICAL COSTS $3 MILLION PER YEAR

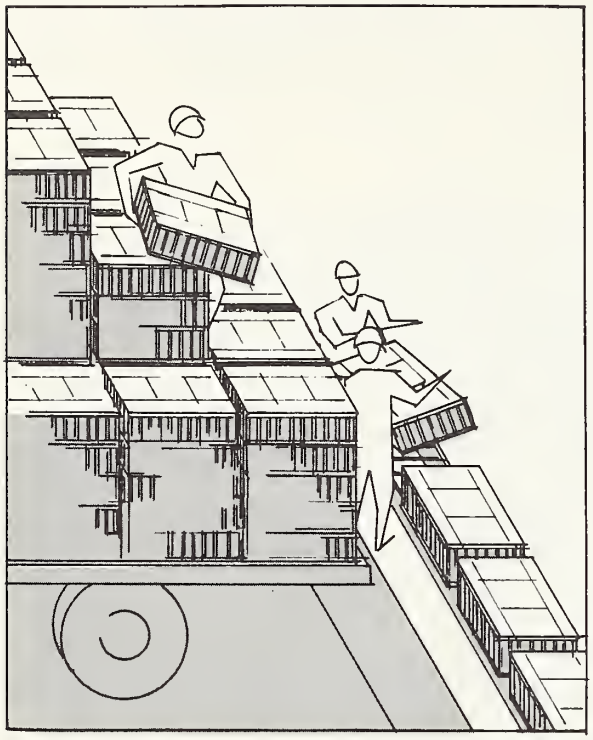
Computerized Processing of Data on Livestock Auction Markets

On most of the Nation's 1,700 livestock auction markets sales data are manually recorded in the auction box and transferred to the market office where a clerical staff prepares the necessary records and accounts. Excessive labor costs are common and errors are costly. To solve this problem, a computer system was developed in cooperation with the University of Missouri and has been used successfully for more than 2 years by a livestock auction in Missouri. However, its use by a single auction market is expensive, so additional research has been done to make it possible to tie several markets into one system. Now the National Livestock Auction Market Association, Kansas City, Mo., plans to install a computer center to service markets within a 100-mile radius of Kansas City. This installation could lead to future computer use on most livestock auctions. The major advantages of the system are that it minimizes the possibility of errors in computations and preparation of records and accounts, speeds up payment for animals following their sale, provides permanent records of all business transacted, and handles all routine accounting tasks such as payrolls. It is estimated that adoption of the system would reduce clerical costs from an average of about 20 cents per animal to about 10 cents. Nationwide, this could amount to a saving of as much as $3 million annually. Payments for "lost" animals also would become a thing of the past.

Causes of Grain Breakage Determined

To assist in overcoming many complaints, particularly from export markets, about the breakage of grain from handling, a study was made to determine the causes of such breakage. This study revealed that corn incurred the most breakage, followed by pea beans, soybeans, and wheat. Breakage increased significantly with the lowering of either moisture content or temperature. The greatest amount of breakage was caused by dropping; throwing was next in magnitude; and handling by bucket elevators resulted in the least damage. Increasing the velocity of movement also increased breakage. The tests showed that 75 percent of the breakage caused by dropping grain 100 feet could be prevented by limiting the drop to 40 feet. Also, handling the grain at moistures near 15 percent and at temperatures above 70 degrees reduced the breakage to one-fifth of that which resulted from handling grain with 13 percent moisture at near freezing temperatures. These results should have substantial impact on the future design of grain elevators and point the way toward improvements in grain handling methods and equipment, which are important in the maintenance of export trade.

IMPROVED HANDLING OF POULTRY

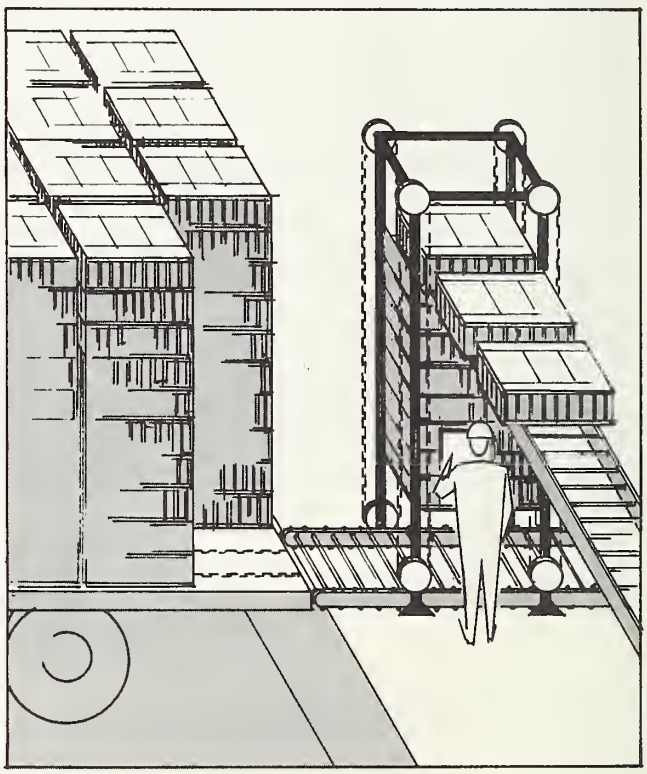


MANUAL

unloading of poultry
costly in bruise damage
and high in labor
requirements

MECHANIZED

unloading of poultry
reduces labor by
two-thirds and
eliminates bruise
damage



POTENTIAL SAVINGS – $1 1/2 MILLION PER YEAR

Mechanical Unloading of Poultry

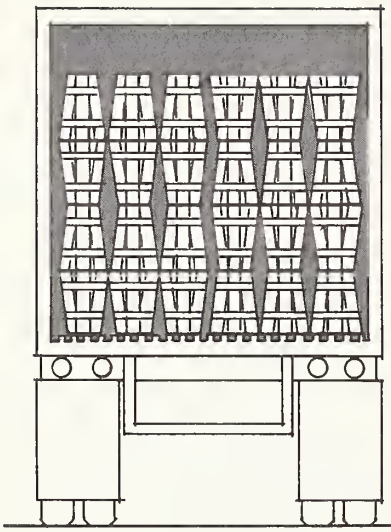
Broilers are transported by truck from farms to processing plants in coops stacked 10 to 12 high. At the plant, three laborers are required to unload the coops and place (usually drop) them onto conveyors which move them to the processing line. The cost of the labor and damage to the birds is excessive. To eliminate this handling and bruising, we have developed a mechanical unloading device which removes the coops from the truck, destacks them, and places them on the conveyor with no labor except for one person to push the buttons that operate the machine. Estimated annual savings from the use of this new equipment should exceed $1,500,000. The research which produced it cost about $75,000.

Humidifying Warehouses Storing Baled Cotton

In the past, baled cotton, stored in warehouses in the semiarid regions, lost moisture and thus bale weight was reduced. To offset this, warehousemen shipped the cotton to more humid areas to regain the lost moisture before being shipped to the textile mills. To reduce this extra cost of storage, yet eliminate the moisture loss, warehousemen in the semiarid areas began humidifying their warehouses. Research conducted at Bakersfield, California, improved this technique and equipment and showed that stored bales could be economically maintained at 7.5 percent moisture content, the same level as conventional storage on the Gulf Coast. Cotton with this moisture content is demanded by textile mills for its spinning quality. Recommendations for the installation and maintenance of automatic controls were accepted by warehousemen for use in 130 installations in California and Arizona.

Improved Peanut Drying Method Increases Drying Rate

A comparison of drying times of the conventional method used throughout the industry for drying peanuts and a modified method employing intermittent blending and intermittent exposure to higher drying air temperatures shows that the modified method resulted in 10 to 30 percent faster drying, with no decrease in milling quality for Starr Spanish, Early Runner, and Virginia 56R peanuts. With the needed refinement in the new drying method and equipment a substantial saving in labor and equipment costs could be realized by the industry together with a reduction in molds that produce aflatoxin.



IMPROVING THE TRANSPORTATION OF PERISHABLE PRODUCTS BY TRUCK

- *PUBLICATION*

  on proper loading, temperature, and humidity for 70 products

and

- *SEMINARS*

  regional and national . . .

WILL HELP

SHIPPERS, CARRIERS, AND RECEIVERS
TO REDUCE $20 MILLION ANNUAL LOSS

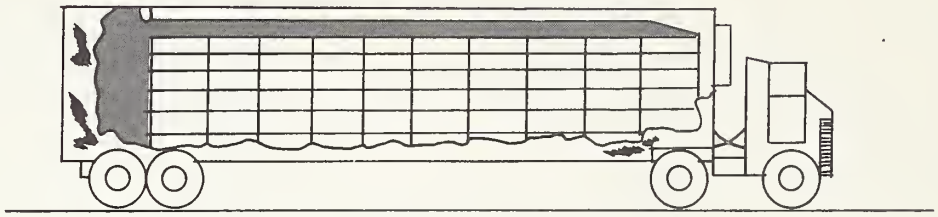
Handbook for Trucking Perishable Foods

A handbook is being published for the use of shippers, carriers, and receivers which gives recommendations for protecting more than 70 perishable products during transit by truck. Information given includes proper loading and stacking methods, temperature and humidity for each product, as well as general information on refrigeration systems used in vehicles. The handbook should contribute significantly toward reduction of the estimated $20-million annual loss from damage to perishables during transport by truck. The American Trucking Association has submitted an advance request for 5,000 copies of the handbook, and it is anticipated that the total demand will exceed the 45,000 requests received for a similar handbook published 14 years ago. Plans are underway to conduct seminars as a means to accelerate dissemination of information contained in the handbook.

Palletization Assists Fresh Fruit and Vegetable Industry

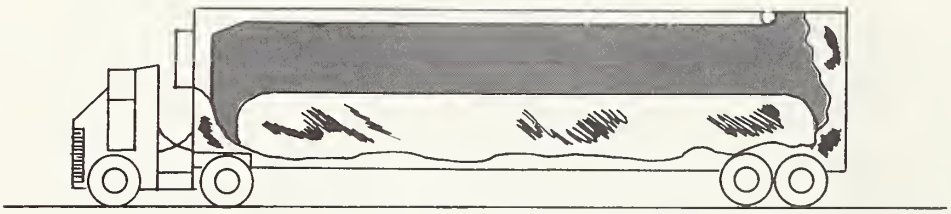
The fresh fruit and vegetable industry can save about $100 million per year by adopting methods of handling and shipping their products in large palletized units to domestic and overseas markets. The complexity of the problem is increased by the relatively small size of fresh fruit and vegetable firms; seasonality of production; antiquated facilities; and numerous other institutional barriers. Researchers have developed methods of unitizing Florida citrus that have been adopted by several shippers. The principles developed in Florida have been applied in Texas with good results. A study of the impact of palletization on the utilization of transport vehicles provides guidance to potential users.

REFRIGERATED TRUCKS DO DOUBLE DUTY



TRUCK FROM THE CITY

DELIVERS PACKAGED FOODS TO RURAL AREA FOOD STORES



TRUCK TO THE CITY

RETURNS WITH 4,500 GALLONS OF MILK, OR FRUIT JUICES, HONEY, VINEGAR, ETC. IN RUBBER FABRIC BAG/TANK

RESULTS:
- LOWER MILEAGE WITH TRUCK EMPTY
- LOWER COSTS
- LESS TRANSPORT EQUIPMENT REQUIRED

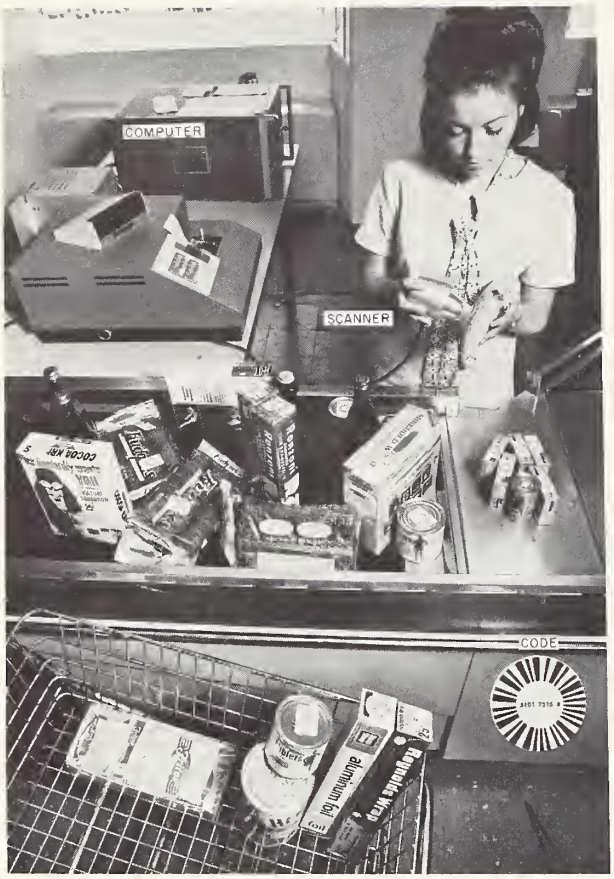
EXAMPLE: CONVERSION OF ONE TRUCK SAVED ONE FIRM $54,600 A YEAR

Reducing Truck Transport Costs

Costs for truck transportation of farm and food products often are higher than they need to be because of poor utilization of transport equipment due to empty backloads. This situation is the result of the vehicles being designed to carry only packaged products, liquids, or dry bulk commodities. Development of a system of transporting bulk liquid food products in large, collapsible, reusable rubber-fabric bag tanks in closed trailer vans has made possible substantial reductions in empty mileage and transport costs for many food products. For example, one food firm is saving 2.4 cents per trailer mile, or $360 on a round trip of 866 miles, by delivering groceries to supermarkets in rural areas and on the return haul bringing 4,500 gallons of whole milk to a metropolitan area processing plant. Yearly savings on this one route are estimated to be $54,600. The firm using this conversion system in the Pacific Northwest now has about six such units in operation. The system also is suitable for transporting liquid sugar, honey, juice, vinegar, and similar products.

New Shipping Containers for Fresh Fruits

Growers and shippers of fresh fruits have requested research to develop shipping containers to replace the more expensive traditional wood containers. Research completed in 1969 on the development and testing of the feasibility of packing and shipping fresh western cherries in fiberboard boxes and in polystyrene foam boxes reveals potential savings of over $\$\frac{1}{2}$ million annually if the new boxes are adopted by the cherry industry. Adoption of new containers usually takes a few years. For example, less costly shipping containers that were developed for marketing fresh eastern-grown peaches several years ago have now almost completely replaced the wood veneer basket previously used. The recently adopted peach containers are a combination wood veneer-fiberboard box and a box made entirely from fiberboard. Including the cost of packing labor, the combination wood veneer-fiberboard box costs 12 cents less than the basket. The fiberboard box costs 25 cents less than the basket. In 1969, approximately 70 percent of all eastern-grown peaches were shipped in combination wood veneer-fiberboard boxes, 25 percent in fiberboard boxes, and the remaining 5 percent in consumer packages, field boxes, and baskets. The switch from baskets to the new boxes represents a saving of $4 million annually to the peach industry and consumers.



NEW CHECKOUT SYSTEM FOR FOOD STORES

USING THE ELECTRONIC SCANNER, CODE, & COMPUTER

PROVIDES THE CUSTOMER:

- FAST AND ACCURATE CHECKOUT
- ITEMIZED LIST SHOWING NAME, COSTS AND PRICE PER OUNCE OF EACH PURCHASE
- VISUAL PRICE AS ITEM IS CHECKED
- POSSIBILITY OF SAVINGS WITH ITS POTENTIAL FOR HOLDING DOWN FOOD COSTS

REDUCES COST OF FOOD RETAILING BY:

- ELIMINATING PRICE MARKING OF EACH ITEM
- ELIMINATING PRICE CHANGING ON ITEMS
- AUTOMATIC AND CONTINUOUS INVENTORY
- AUTOMATIC ORDERING FROM SUPPLIERS

New Checkout System for Food Stores

Performance specifications developed for an improved checkout system for food stores have resulted in a completely computerized checkout system which is now undergoing engineering and economic evaluation by ARS. The key component of the system is an electronic scanner that "reads" a code placed on the package before it is delivered to the retail store. The code is identified in a computer with a specific size, brand, weight, and price of a food item. When the item is checked out, the scanner reads the code and the item's price is immediately shown, as at present, on the cash register. After all of the customer's items are checked, she receives a list of all of her purchases, which identifies each item by name, cost, and price per ounce. It also shows the total cost of the order, the number of stamps (if stamps are given), and the tax on taxable items. The system will be free of cashier ring-up error. In addition to speeding up the checkout operation and furnishing the customer with an itemized list of her purchases, the new system holds promise of reducing or holding down the prices she must pay. Retailing efficiencies may be obtained through eliminating the labor of price-marking and price-changing, eliminating the labor of physically checking the shelves for merchandise replacement and of filling out order sheets, better control of inventories, and managing the store more effectively through the use of the detailed data made available. Additional efficiencies are possible at the warehouse. The development of this checkout system is expected to change the distribution system very significantly.

Reducing Costs of Exporting U.S. Agricultural Products

Agricultural exports of over $5 billion annually are a significant part of total U.S. exports, are vital to U.S. agriculture, and contribute over $1 billion to our international balance of payments. The Transportation and Facilities Research Division is conducting research to reduce transport and packaging costs, to reduce losses and pilferage, to improve transport services, and improve the competitive position of U.S. products abroad. Research on poultry exports reduced handling individual packages from 12 times to two, reduced losses and pilferage by 70 percent, reduced transit time by one-third, reduced labor costs by 85 percent, and reduced packaging costs by 47 percent. Research on exporting radishes reduced labor and material costs for loading 42 percent. The establishment of a European field station in Rotterdam has reduced the cost of doing the research and expanded the program to many other commodities. Potential savings from this research on exporting U.S. perishable commodities such as animal products, poultry, fruits, and vegetables are $224 million per year.

Problems and Objectives

Food moves through a succession of marketing facilities on its way from farms to consumers. Near farms, there are facilities for the assembly and preparation of the products for distribution to urban areas. In the urban areas, there are facilities for receiving this food and, with or without further processing, moving it on to retail outlets and consumers. Many of the facilities in use are outdated, inadequate, and costly to operate. The costs of handling food through them often is 25 percent more than would be necessary in modern and efficient facilities.

The major objectives of the research in this area of work are to reduce the costs of food marketing and to provide an orderly, efficient food distribution system by:

1. Providing technical assistance in planning improved facilities.

2. Promoting the development of improved facilities.

3. Developing criteria and technology for planning improved facilities.

Facilities in Urban Areas

During this year studies were made and plans developed for improved food distribution facilities to help hold down the costs of marketing food in five urban areas. These studies assist local government officials, food handlers, industry groups, and civic organizations in planning improved, modern, and efficient facilities and methods for handling food. These investigations are concerned with the proper type, size, composition, design, location, cost, and economic feasibility of new or improved facilities. Furthermore, the studies focus attention on major problem areas and thus act as a stimulus by emphasizing the need for recommended improvements. Highlights of the current urban studies are as follows:

Los Angeles, California.--In Los Angeles, many interested groups including trade organizations, labor unions, food industry representatives, and food wholesalers became concerned with the inadequacy of wholesale marketing facilities in that city. Their concern was expressed to city officials, and as a result the Mayor and City Council requested that a study of the situation in Los Angeles and Orange Counties be undertaken. Included in the study were distributors of fresh fruits and vegetables, meat and meat products, groceries, poultry and eggs, manufactured dairy products, fish and shellfish, and full line distributors both independent and chain. A commodity specialist was assigned to study and determine the needs of each group. The Department of Interior took the responsibility for fish and shellfish. These specialists

have interviewed and collected data from 500 firms, about 250 of which need new facilities. The types and sizes of facilities required were determined, and this information was used to develop a master plan which provides in excess of 2 million square feet of first floor space in 52 buildings. To accommodate the recommended facilities, expansion area, and space for food related facilities will require about 470 acres. Some 25 sites have been analyzed and reduced to six which are representative. The cost of constructing these facilities is being developed currently. Also possible methods of financing the entire project are being investigated. A report is now being written for oral presentation and publication which will set forth the facts on the present situation; recommend the size, design, and possible locations for a proposed new food distribution center; show the estimated cost of providing such a center and the rentals that will be necessary to support it; and evaluate the savings in food handling costs and other benefits that can result from such a development.

Oakland, California.--Work on this project was completed. Plans were developed for new facilities which provide over 500,000 square feet of floor space for 92 wholesale food firms serving the Oakland-East Bay area. The total cost of land and facilities is estimated to be $12.6 million. A report of this study has been written and is being published.

Denver, Colorado.--Plans have been developed for a new food distribution center in Denver which would provide facilities for 65 food wholesalers on a site of about 50 acres. The total cost of land and facilities was estimated to be about $10 million. Construction has begun on the "Western Food Center" adjacent to the Denver Union Stock Yard. A combination cold-dry storage facility has been built, and a modern cold storage warehouse is under construction. This warehouse will be constructed in two phases with the first phase containing 76,000 square feet and the second raising the capacity to 186,000 square feet. Two other warehouses are slated for construction in the near future--one containing 50,000 square feet and the other 75,000 square feet. All these facilities will permit stacking products 21 feet high in storage areas. Other facilities are in the planning stage. The report on this study has been presented orally in Denver and is now in process of being printed.

Minneapolis, Minnesota.--Plans have been submitted to the Minneapolis Industrial Development Commission for the development of an $8.7 million food distribution center on a 70-acre site in the Elm Street industrial area of Minneapolis. These plans incorporate earlier studies made by this Division.

Altoona, Pennsylvania.--Work on this project was completed. New facilities with over 359,000 square feet of floor space for 20 independent firms, plus an additional 30 acres of land for a corporate food chain warehouse, were recommended. Total investment required was estimated to be in excess of $5.8 million, excluding facilities for a central energy plant and the corporate food chain warehouse. A report of the study has been published.

The following items summarize progress on research of specific problem areas associated with the planning of food distribution centers in cities:

Determine the most efficient system for supplying refrigeration to buildings in food distribution centers.--Three refrigeration systems were studied for food wholesalers in a hypothetical food distribution center: (1) One central refrigeration system for the entire center, (2) a system in each building in which several firms are housed, and (3) individual refrigeration units for each food wholesaler. The study showed that the most efficient and least costly of the three systems is a central refrigeration system for the entire center. A system in each of the buildings would cost 8.2 percent more to install and 25.4 percent more to own and operate than the central system. Separate refrigeration units for each firm would cost 4.3 percent more to install and 61.9 percent more to own and operate than the central system and would not provide heating and air conditioning for offices. A report of this study is being published.

Determining requirements for central refrigeration facilities in a food distribution center for Los Angeles.--The wholesale food distribution center proposed for Los Angeles would require about 7,300 tons of refrigeration (per hour) at peak loads. This refrigeration could be produced at the lowest cost by using one central refrigeration system for the entire center. The installed cost of the system would be about $8.8 million. The cost of owning and operating the system would be about $2.23 million per year. During the first 10 years of operation, the refrigeration cost to firms served by the central system would be approximately 25 percent less than if they were using individual refrigeration units. In addition, the firms would not have to invest the capital that would be required if they were to supply their own refrigeration equipment. The report describing this system and its cost is being published.

Plans, specifications, and construction costs for multiple-occupancy wholesale food facilities.--Construction designs that eliminate the need for interior support columns were developed for multiple-occupancy buildings (buildings which house more than one wholesale food firm) in wholesale food distribution centers. Clear-span buildings can be built for essentially the same cost as buildings having support columns because of savings derived from the elimination of columns. Findings are being applied in current wholesale food distribution facility planning work. The omission of columns gives better utilization of floor space, facilitates handling, and makes it easier to consolidate smaller stores into larger units.

Production Area and Specialized Facilities

Most food products begin their movement in the marketing channel at assembly facilities located in producing areas. These are usually facilities where products are assembled from farms and graded, packaged, stored, or otherwise prepared for movement to wholesale and retail outlets. Investigations include research and technical guidance on the design, layout, and cost

of such facilities; the types, locations, and combinations of equipment needed within the facility; the operational procedures that should be followed; and the best work methods and techniques for obtaining maximum efficiency. This program is designed to study and analyze needs in particular locations and to make recommendations that could result in more efficient marketing of specific commodities. The following work in this area was completed during the year:

Poultry and eggs.--Several studies were conducted to plan and promote the development of improved facilities for handling poultry and eggs. One of these studies, conducted in cooperation with the Alabama Department of Agriculture and Industries, was to develop plans for a new egg grading and packing plant in Boaz, Alabama. The firm was operating in an old, multistory building in a congested area where processing and handling efficiency was limited. Its operating costs are expected to be reduced by at least 15 percent when it moves into the new, 20,000-square foot plant in August 1970. Assistance also was provided to a poultry wholesaler in Florence, Alabama, who now has moved into a new facility in an industrial park. Plans were developed for a poultry processor and a turkey processor in Kansas whose facilities were to be closed because they did not meet the requirements of the Wholesome Poultry Act. The Kansas State Board of Agriculture plans to use these two plants as models to show to other processors in the State how to improve their facilities. Construction is underway at both plants. In a fifth study, plans were developed for a new processing plant for fowl in Wisconsin to replace an old, inefficient plant.

A report entitled, "Improved Layouts for Boxing Frozen Turkeys," ARS 52-37, was published during the year. The adoption of recommendations in this publication will enable many turkey processors to reduce their labor costs for boxing turkeys by 15 to 25 percent. Letters requesting copies of this publication have been received from firms in 24 States and five foreign countries. Another publication entitled, "Planning a Wholesale Poultry Layout in a Multiple-Occupancy Building" has been written. A study of a duck processing plant in Long Island, New York, is being conducted in cooperation with the New York Department of Agriculture. The objective of this study is to reduce costs through improving the methods and facilities in an existing plant. Two conferences were held for a group of managers of farmer cooperatives from Brazil to discuss methods and facilities for marketing poultry and eggs in the United States and their possible application to Brazil.

Fruits and vegetables.--A joint study with the Farmer Cooperative Service was initiated during the year under contract with the Four Corners Regional Commission headquartered at Farmington, New Mexico. Objectives are to determine the feasibility of assisting the apple industry in eligible areas of New Mexico, Colorado, Utah, and Arizona through the establishment of improved packing and storage facilities and some centralized selling agency, under cooperative or other ownership and management. Preliminary field investigations have been made and substantial background information developed for defining the structure of the industry throughout the region. - In Lansing,

Michigan, a study of the problems involved in the relocation of its Municipal Market was completed, and a report recommending one of alternative proposals was submitted to city officials. - In cooperation with the Louisiana State Market Commission and the City of Alexandria, Louisiana, recommendations were developed concerning the marketing of produce grown in the area. - Design and layout assistance to the Dade County Growers Cooperative Marketing Association, Miami, Florida, was begun in the planned replacement of one of its sales buildings on the Miami Wholesale Market. - New warehouse and packing facilities for which planning assistance had been provided were completed at Columbus, Georgia, and at Dothan, Alabama.

Dairy products--Three studies to improve facilities and methods of operating dairy plants were made to reduce the cost of processing, handling, and distributing these products. In the first plans were developed in cooperation with the Colorado State Department of Agriculture for a new dairy products processing plant in Greeley. The new facility was designed for processing a 50-percent increase in volume of fluid milk, ice cream, and cottage cheese. The proposed facility, containing approximately 10,000 square feet of floor space, incorporates a new milking parlor and barn on a 40-acre site. By combining the processing and milking operation into one properly designed facility, no additional labor will be required to handle the 50-percent increase in volume. A part of the proposed facility has been built and the remainder is scheduled for completion this summer.

A feasibility study was made and plans developed, in cooperation with the Extension Service at Virginia Polytechnic Institute, for a new milk processing plant and retail store in Lee Hall, Virginia, to be operated by a dairy farmer. The proposed facility will process and market the farm's annual production of approximately 220,000 gallons of fluid milk, and retail specialized foods and a limited line of groceries. The study showed that the operator could increase his net return by approximately $29,000 a year by building and operating the proposed facility. The construction of the facility is expected to begin soon.

In cooperation with the Extension Service at the University of California, an improved processing and handling facility in Los Angeles was designed. Because of crowded conditions and lack of space for expansion, the firm relocated into a remodeled facility designed and equipped for processing and handling a 50-percent increase in volume. Further study is being made to determine additional changes that will lower operating costs. The experience with this plant will be incorporated into data collected in other dairy processing plants and used in developing a publication which will compare the plant operating costs in remodeled plants versus new plants.

Livestock and meat.--A report entitled, "Guidelines for Establishing Beef Packing Plants in Rural Areas," is near completion. A popular "Agriculture Information Bulletin" on the subject is being written, in cooperation with the Publications Branch, Information Division, and also is near completion.

Grocery warehousing.--This work is concerned with assisting grocery wholesalers in minimizing their costs of doing business by designing efficient warehouses and improving the ways foods is handled in these wholesale facilities. As a part of this project, plans were developed, in cooperation with the Genesee Valley Regional Market Authority and a local supermarket chain, for a large grocery warehouse in Rochester, New York. It was anticipated that this warehouse would be located on a food distribution center operated by the Authority near the City. Construction of the proposed 300,000 square-foot wholesale facility would complete development of the Rochester market. The new building would service stores owned by the supermarket chain with a complete line of food products.

Another study was conducted in cooperation with an independent grocery wholesaler in Jackson, Mississippi. This study developed methods for improving operations in existing facilities and provided plans for a new 54,000-square-foot grocery warehouse to serve the company's future needs. The research showed that the cooperating grocery wholesaler could reduce his labor costs by approximately 26 percent in existing facilities, and still more in the new facilities. The new warehouse would allow the wholesaler to expand his present business volume. Insufficient land is available at this present location for such expansion.

Research on grocery warehouse facilities also is conducted as a part of broader studies to develop plans for wholesale food distribution centers in large cities. This work assists large groups of wholesalers in improving their facilities and handling methods. Many institutional grocery wholesalers in metropolitan areas need to construct new warehouses to replace outmoded facilities, or to make way for urban renewal programs. Some of these firms may consider relocating on a local food distribution center. While large wholesalers can make use of a considerable amount of published research on efficient warehouse designs and handling methods, small grocery wholesalers have been forced to rely on their own resources. In order to assist these small wholesalers, research was conducted to aid in developing plans for facilities designed specifically for their needs. A draft of a report entitled "Layouts and Equipment for Institutional Wholesale Grocers in Multiple-Occupancy Buildings in Food Distribution Centers," has been prepared for publication. This publication will show small grocery wholesalers how to share a common building and utilize many of the efficient warehousing methods used by their larger competitors.

Preliminary and Followup Work In Specific Locations

Exploratory investigations are made before any major study is undertaken. The nature and extent of, and needs for, the study are analyzed in order to decide whether or not it should be made and to allocate the proper personnel and resources. After studies are completed, followup assistance often is necessary to help planners solve problems of financing, organization, construction, and management. Where new facilities have been built, followup assistance frequently is provided to implement the recommendations and thus

bring about maximum savings in food handling costs. Preliminary and followup work, ranging across most commodity lines and including marketing activities in both urban and producing areas, were made during the year in the following locations.

Baltimore, Maryland.--The grading and preparation of the site for the new Baltimore Regional Food Distribution Center is near completion. Agreements have been completed to provide utilities and rail service to the area. This site is located between Baltimore and Washington and will be capable of serving these two major urban areas. Negotiations presently are underway between the Baltimore Regional Market Authority and a regional full line distributor which will enable this chain store to acquire a substantial acreage at the site. Architectural plans have been completed for the fresh fruit and vegetable section of the market. Twenty-one letters of intent have been received from local wholesalers. The State of Maryland has appropriated $5 million toward construction funds. In a report released by this Division, which provides details on the proposed facilities, it is estimated that when completed the market would cost in excess of $22 million.

Boston, Massachusetts.--As a result of studies by the Division, Boston has some of the most modern food distribution facilities in the country. The recent construction of the $8.5 million addition to the previously built meat facilities in South Boston completes the relocation of the major portion of the city's meat wholesalers. This also completes the relocation of food firms from the old Faneuil Hall Market which had been in continuous operation since the early colonial period. The construction of the Boston Fruit and Produce Auction this year in the Everett-Chelsea area, adjacent to the New England Produce Center and the Boston Terminal Market, will complete the relocation of the fresh fruit and vegetable distributors. Several grocery firms also are located at this site.

Adjacent to the new meat distribution center, facilities for the new Boston Flower Exchange are nearing completion. The Exchange Building will serve as the nucleus of a relocated Boston Florist Market. The site and plans for this market were recommended in a Division report published in 1962.

Detroit, Michigan.--Division specialists met with representatives of the food industry, city and State agencies, Michigan State University, and the Office of the Mayor concerning a proposed food distribution center for Detroit. A series of meetings with various segments of the food industry and the City are scheduled to reaffirm the extent of industry support, obtain guidelines in establishing priorities, and determine immediate and long-term acreage required for such a center. The Division will provide technical assistance as needed.

Honolulu, Hawaii.--Representatives from the Hawaii Department of Land and Natural Resources visited Division specialists at Hyattsville to discuss the development of the new wholesale food distribution center planned by the Division for Honolulu. It is expected that the site will be prepared and

ready for the construction of new facilities by early 1971. Construction specifications for the facilities are 90 percent complete. The design of the center follows the Division plan outlined in its publication (MRR-821) issued in 1968.

New York, New York.--In the Hunts Point food distribution center, a fruit auction and large warehouse are under construction. Ground-breaking ceremonies were held for the construction of new wholesale meat facilities on a 37-acre site adjacent to the fruit and vegetable market. Leases have been signed that involve over $58 million in new facility construction in this area. The Division did the planning and has provided technical assistance through the years to implement its research recommendations. Recently, assistance was provided food merchants and city officials concerning the feasibility of the fresh fruit and vegetable wholesalers leasing and operating the fruit and vegetable section of this city-owned distribution center.

Oakland, California.--Fresh fruit and vegetable wholesalers in Oakland are attempting to acquire a site within the city to develop their new market. A tract of land at the Port of Oakland is under consideration. The Division's specialist who made the original study evaluated this site and recommended that additional acreage be acquired to provide adequate space for the proposed development.

Philadelphia, Pennsylvania.--The $100 million wholesale food distribution center in Philadelphia, built as a result of research conducted by this Division, has achieved its development goal five years ahead of the target date of 1974.

Raleigh, North Carolina.--Assistance was given to the State Farmers' Market with the design of additional facilities under construction in the market and on further market development. A new 11,000-square foot grocery facility is the latest addition to this market, which was constructed after a study by this Division released in 1950.

Wilkes-Barre, Pennsylvania.--Division specialists met with representatives of the food industry and the City of Wilkes-Barre concerning their request for assistance in the planning of improved wholesale food distribution facilities for the area. A commitment was made to begin a study during the first quarter of FY 1971.

Special Research and Technical Assistance

The Division is called upon to assist in special problem areas which relate to the distribution of food in specific situations. This work may be in cooperation with private industry, contractors, or other branches of the Federal and State government. In addition, limited assistance is given to representatives of foreign governments in helping them plan improved marketing facilities in their respective countries. Such assistance is usually coordinated with the State Department. Meetings for foreign representatives are

arranged with food industry representatives in this country, along with tours of marketing facilities.

The following summarizes special research and technical assistance during the past year:

Guidelines for minimizing damage to the food processing industry in case of nuclear attack.--A report entitled, "A Facility Protection Handbook on Minimizing Damage to Food Processing Plants in Case of Nuclear Attack," has been completed and is in process of publication. The handbook describes the possible effects of nuclear weapons on food processing plants and the measures that can be taken to protect them.

Fallout radiation shielding for food distribution centers.--The Division cooperated with the Office of Civil Defense in a study to determine how shelter protection can be attained in wholesale food distribution centers for metropolitan areas. The study, which has been completed, shows that most buildings offer good fallout protection now and that additional protection can be attained at little or no additional cost. The Office of Civil Defense will provide advisory assistance to planners and developers of metropolitan area food distribution centers in providing for maximum fallout protection.

Johannesburg adopts Division recommendations.--The City of Johannesburg, Union of South Africa, revised its master plan for new food marketing facilities to include recommendations made by the Division. The cost of the facilities, including land, will be about $11.2 million. Completion is scheduled for 1970. Specialists in the Division conferred with representatives of that city on several occasions when they came to the United States for help, and by mail gave other technical guidance as requested.

Mexico City adopts Division recommendations.--Representatives from the Mayor's office in Mexico City, including an architect, spent several days in the United States with members of the staff of this Division obtaining information they could use to plan a new food distribution center for 2,000 food wholesalers and processors in that city. Upon their return to Mexico, they made a study and developed a plan, and returned to Hyattsville to review their plan with Division specialists. They incorporated recommendations made by the specialists into their final master plan. When completed, this food market in Mexico City will cost over $90 million and employ over 15,000 people.

New food distribution center planned for Santiago, Chile.--Division specialists in Hyattsville spent several days with representatives of the Government of Chile assisting them in planning a full-scale food study in Santiago. The Chilean representatives visited major food centers suggested by the Division prior to their return to Chile.

Publications and Papers

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ASSEMBLY AND STORAGE OF FIELD CROPS

Problems and Objectives

Improved varieties of many field crops with their increased yields, along with progressive cultural and harvesting practices, require improved techniques and equipment for economically handling, conditioning and storing these crops in marketing channels. Grain now must be handled and conditioned in large quantities in a short period of time yet its quality must be maintained and labor and other costs minimized. Although product deterioration in storage has been reduced in recent years due to increased acceptance of aeration, shrinkage from loss of moisture is still a factor as well as loss from handling. Physical damage to the product must be reduced to maintain a high standard of quality. Because certain field crops are susceptible to contamination by toxin-producing molds, conditioning techniques and equipment must provide mold inhibiting environments.

Major objectives of this research are to:

1. Determine requirements essential to the development of improved techniques, equipment, and facilities for conditioning, drying, storing, and handling field crops.

2. Develop and test improved techniques and equipment for drying and storing field crops while maintaining desired standards of quality.

3. Develop and test improved techniques and equipment for the efficient handling of field crops yet minimize physical damage to the product.

4. Develop and test improved techniques and equipment to prepare field crops for market.

5. Establish design principles and improved facilities for commercial storage of field crops.

Progress

Cotton and Cottonseed

Improved techniques, equipment, and facilities for handling and storing baled cotton in warehouses.--Features of improved baled cotton storage compartment designs and layouts were included in 44 new compartments constructed in California, Arizona, New Mexico, and Texas. One feature, doors 14-feet wide by 16-feet high, permitted unloading bales from road trucks inside the compartment. Tests showed that the two clamp trucks used in conventional unloading could be reduced to one, and the three trucks used for stacking could be reduced to two. Wide work aisles permitted improving shipping

operations through the use of 32-bale clamp trucks. A study of selected costs of handling baled cotton showed that detailed time study data obtained during a 10-year period can be analyzed systematically to project marginal costs of handling.

Improved techniques and equipment for humidifying stored baled cotton.--Applied research studies show humidification of baled cotton storage compartments in semiarid areas should be automatically controlled at 65% relative humidity. A properly installed system of the pneumatic syphon atomizer type prevents moisture loss and fiber damage during storage at an annual cost of 20-50 cents per bale. Baled cotton that has been in humidified storage for at least 3 months after ginning will regain and maintain 7.5% moisture content. Development of improved automatic controls has increased reliability and uniformity and eliminated excessive humidification, which damages cotton. Recommendations on installing and maintaining controls was accepted by managers of 130 storage compartments in California and Arizona. A publication on moisture regain of bagging is in final editing.

Handling, drying, aerating, and storing cottonseed in commercial storages.--During 1969-70 cottonseed aeration studies were continued. A static pressure survey of a previously modified system indicated airflow was well distributed using the unloading tunnel as the only aeration duct; cottonseed cooling was uniform, requiring less quality check time; and quality maintenance and germination provided a high quality planting seed. In a test conducted in February 1970 in a 14,000-ton storage, 3,840 hours of fan operation provided an average mass temperature of 49° F. Removal of hot spots resulted in some fan operation with no mass cooling. Static pressure data from one quandrant of the storage has not been fully analyzed. Initial moisture contents of 14% and 18% were used in repeated lab drying tests to determine the effects of temperature and airflow rates on germination. Drying air temperatures of 110° to 140° F. with airflow rates of 20 and 60 cubic feet per minute (c.f.m.) were used. Some germination loss occurred at 110° and losses increased with increase in temperature. Some germination loss occurred in storing 18% seed at 35° F. for extended periods. Final samples of the 1968-69 tests taken July 1969 at the Delta Station revealed no aflatoxin produced during the 240-day storage period under the same storage environments as 1967-68. Laboratory tests started June 1970 use field infected cottonseed with moisture contents of 14%, 17%, and 20% in aerated and non-aerated bins duplicated at storage temperatures of 80° and 85° F. The Market Quality Research Division will make assays for mold growth and aflatoxin.

Optimum conditions for storing cottonseed to minimize molds and mycotoxins.--Work was continued at Mississippi State University under a Cooperative Agreement on laboratory studies on the growth and production of aflatoxin using different growth media of potato dextrose agar (PDA), modified Czapeks medium, commercial cottonseed meal, and homemade cottonseed meal at various temperatures. Indications are that mold growth may occur at temperatures of 8° to 16° C. without the production of aflatoxin. Also, observations indicate that aflatoxin produced at some higher temperatures (29° to 32° C.),

can sustain relatively lower temperatures during the storage period. Other indications in different isolates show some strains may grow slower but over a wider range of temperatures than others. All isolates produced aflatoxin on PDA at 36° C. in 24 hours. In contrast, no aflatoxin was produced by any isolate grown on commercial cottonseed meal at 32° C. for 24 hours. Other researchers have isolates of A. flavus that will not produce aflatoxin on PDA. Maximum growth rate of all isolates on commercial cottonseed meal was at 32° C. with a sharp drop at 28° and 36° C. over a 5-day period. A final report should be forthcoming from the Cooperator on or after June 1970 covering the work on this Cooperative Agreement.

Cereal and Feed Grains

Improved techniques and equipment for conditioning, drying, and storing corn at commercial facilities.--Partial drying of field-shelled corn with heated air and finish drying by aeration with outdoor air was further investigated with the 1969 crop. The corn was dried with heat from about 27% to 20% moisture, moved to a storage bin, tempered 4 hours, and then cooled with aeration at airflow rates of 0.3, 0.5, or 0.7 cubic feet per minute (c.f.m.) per bushel. Aeration was continued during storage. Although the corn moisture was above 16% on April 1, a limit indicated by previous tests, two lots aerated at 0.5 and 0.7 c.f.m./bu. dried before excessive mold growth occurred. The lot aerated at 0.3 c.f.m./bu. averaged 17.9% moisture on April 1, and molded extensively by May 15. Stopping the heat drying at 20% instead of 16% moisture reduced breakage susceptibility by 43% and increased dryer capacity by 50%, both objectives of the partial drying technique.

Corn field-shelled at 21.4% moisture and aerated with either refrigerated or outdoor air was maintained in good condition until mid-May, even though all lots were above 17% moisture on April 1. By mid-May the continuously aerated lots had dried to 14.5%, while the refrigerated lots, at a lower temperature, remained above 17% and molded.

Other work involved graduate students and included research on grain metering, on a mathematical simulation of the grain receiving and conditioning functions of an elevator, and on a laboratory evaluation of cooling heat-dried corn.

Improved techniques and equipment for conditioning wheat, grain sorghum, and corn in commercial storages.--Storage tests with corn field-shelled at 22% moisture content compared ventilation with outdoor air to ventilation with air mechanically conditioned to 33°-35° F., 43°-45° F., and 53°-55° F. Air was forced upward in the 145-bu. bins at a flow rate of 0.5 c.f.m./bu. In the outdoor bin, corn moistures in the bottom 1 foot were reduced to 15% in 25 days, and in the bottom half of the bin to 15% in 75 days. After 125 days, corn moistures ranged from 12% at the bottom to 15% at the top. Little mold damage occurred, the corn graded No. 1, germinated 87% and had a fat acidity value under 20 when the test was concluded on March 10.

In the indoor bins held at constant temperature, moisture removal was slower and required 90 days to reach the 15%-17% level in the bottom half of the bins. The corn held at 55° F. and 45° F. had over 50% of the kernels invaded by storage molds after 3 months, while the corn held at 35° F. had no mold growth or other changes. In descending order of storage temperatures, the final germination percentages were 70, 84, and 95; fat acidity values were 39, 25, and less than 20.

Improved design principles and operating methods of handling equipment to reduce grain damage.--Physical properties of grain, including bulk density, porosity, sphericity, breaking strength, and internal damage were determined in a continuing study of the effect on these properties of year-to-year variations, variety, and location where grown. Evaluation of corn samples used in the Cargill tests on physical damage from handling showed that the breaking strength of corn was affected by the number of stress cracks in the kernels. The average breaking strength of 20 kernels in the flat position ranged from 66 pounds for kernels without stress cracks to 47 pounds in checked kernels. A laboratory evaluation of impact damage to corn showed that kernel velocity was the single most significant factor in breakage and that breakage was higher in lower moisture corn. The damage was five times greater with steel and six times greater with concrete than with urethane as the impact surface. The damage was 25% less when the impact angle was 45° rather than 90°. In pneumatic conveying tests, the damage to wheat was much less than to corn; damage to soybeans was intermediate.

Peanuts

Improved techniques and equipment for handling peanuts at commercial storages.--Time studies were made on unloading Spanish peanuts from bobtail and tractor-trailer trucks with pneumatic conveying systems. An air pipe operator and a truck driver were required to unload. The truck driver was not paid by the warehouse. The air pipe operator determined the rate of unloading and degree of damage. The average rate was 22.4 tons/hr. The percentage of damage increase was: split kernels, 1.2%; loose shelled kernels, 0.8%; and cracked or broken pods, 3.7%. Initial and final grade analyses on tempered peanuts showed an average of 2% sound mature kernel reduction--a potential $6-$8/ton loss to buyers. Initial and final analyses were made 2 hours and 18 hours after drying. Air tempering did not affect the grade. Using a 4" x 6" bucket elevator to convey Virginia peanuts increased split kernel damage 0.16%; loose shelled kernels, 0.18%; and cracked or broken pods, 1.7% for each conveying. The belt speed affected split kernels the most; bucket loading affected loose shelled kernels and cracked or broken pods the most; and the greatest amount of damage in total was by belt speed. Samples were obtained from trailers and from fields for cracked or broken pod analysis. Pod damage was 25% to 88%, the average being 69.3%. Air conditioning entering and leaving the peanuts did not give a reliable correlation with moisture content. The ambient air and air flow rate variations were the primary causes.

Improved techniques and equipment for drying and storing peanuts at commercial storages.--Air mechanically refrigerated and then heated to 40° or 60° F. was used to dry peanuts. Peanuts were of lighter color and poorer flavor than peanuts dried conventionally. The milling quality was lower for peanuts dried with low humidity air. Low temperature drying was impractical due to expensive, specialized equipment and lack of a quality product. Infrared drying was unsuccessful due to equipment limitation of applying heat. Drying in bin-type dryers, using periodic blending and short exposure high temperature treatment, was 10% to 30% faster than the common method. No increase in shelling damage or aflatoxin production to Starr Spanish, Early Runner, or Virginia 56R was noted. Mature kernels had a slightly lower moisture content than immature ones during storage. Procedures were developed to rewet pods and redry hulls for improved shelling. The difference in storage environments was not significant for aeration tests on stored farmers' stock peanuts. Tests were initiated to determine the optimum storage environment for shelled peanuts.

Developing new and improved methods, equipment, and techniques for shelling peanuts.--The size properties of Florunner, Early Runner, Starr Spanish, Florigiant, and 56R varieties of peanuts were obtained for FY 1969. The Florunner pod and kernel diameter was 5%-10% larger, slightly shorter, and of a more uniform shape. The kernel was more eccentric and the hull was 0.005" thinner than for the respective properties of Early Runner peanuts. The properties of other varieties were similar to prior years. The best size grouping for presizing Runner peanuts was 50%, 30%, and 20% to the first, second, and third stages of shelling, respectively. Presized Runner peanuts, by combination of pod size and specific gravity, gave 7% higher shelling efficiency and 0.3% fewer split kernels than unsized. Tests on commercial type shellers indicated definite improvements by: improving bar and grate design; using correct sheller speeds, grate sizes, and distance between bar and grate; and improving feed techniques. Operation process charts were developed for new commercial and seed shelling plants. A comprehensive evaluation was made of the shelling properties of Florunner peanuts. The shelling rates, efficiencies, and out-turn were higher than for other Runner varieties. A shelling plant was set up similar to that for Early Runner. A short-slotted screen was needed to drop eccentric kernels. Eccentric kernels and thin hulls were possible sources of shelling trouble with Florunner peanuts. Generally, Florunner peanuts have good shelling properties. Cooperative work with the Market Quality Research Division determined the effects of insect infestation on shelling out-turn. There were lower out-turn and higher milling losses at higher infestations. Normally, insects were found in loose shelled kernel peanuts which were taken out by the cleaner.

Rice

Improved techniques and equipment for drying and storing rice at commercial facilities.--A portable dryer of the concurrent flow type was tested for drying rough rice to determine the drying rate and the effect of this type of

drying on milling yield. With the flow rate adjusted so that rice was exposed to 135° F. air for 160 minutes in a single pass, Saturn variety rice was dried from 22% to 16% moisture content, but with a drop of 12% in head rice. Improved performance resulted by reducing the exposure time, increasing the heated air temperature, and using a multipass operation. For example, Belle Patna variety rice was dried from 22% to 16% moisture content in two passes with 25 minutes' exposure to 200° F. air each pass, and no change in milling yield was noted. This portable dryer was less convenient for multipass drying than a columnar, continuous flow, heated air dryer in which the directions of air and rice movements followed no fixed pattern (mixed-flow type).Rice with initial moisture content of 15% to 16% was stored in aerated bins from August 1969 to March 1970. Two varieties, Bluebelle (long-grain) and Nato (medium-grain), were included in storage tests. Bins were sampled initially, then at monthly intervals. Market quality was maintained through the storage period for rice in bins aerated at rates of 0.3 cubic feet per minute per cwt. or higher, according to Consumer and Marketing Service Grain Division grade certificates. No aflatoxin was detected in assaying portions of each sample.

Tobacco

Improved techniques and equipment for handling unprocessed tobacco in warehouses.--A belt conveyor receiving system was designed, tested, and accepted commercially for handling sheets of tobacco without using baskets at warehouses. Warehousemen purchased, installed, and used 12 systems before the ARS prototype testing was complete. The system increased the handling rate to 2.94 sheets/min. with an 8-man crew. One warehouse received 5 sheets/min. with a 7- to 10-man crew during the 1969 marketing season, compared to 22 men in the prior season. Labor and equipment costs averaged 80 cents/1,000 pounds for warehouses receiving 7 million pounds annually. Scheduling tobacco into auction warehouses was successful. Growers were scheduled so tobacco was delivered at a 10-trucks/hr. or 150-sheet/hr. rate. Random arrival spaced the trucks throughout the hour.

Systems analysis of handling flue cured tobacco in marketing channels.--Data were obtained from nine tobacco companies on labor and equipment used in receiving tobacco for use in a market system analysis. Other input data obtained for the simulation model of the flow of flue-cured tobacco through the system showed 41,519 farm trucks hauled 839 million pounds of tobacco in 1969 from packhouses in Florida-Georgia, South Carolina-Border, and Eastern belts to 191 sales warehouses. Research continued to develop a package for unprocessed tobacco to be used from farm to processor or for export. Of the 10 sizes analyzed, two were selected for further testing. A disadvantage is that only 22,000 pounds of tobacco can be placed in a van container compared to current truckloads of 27,000 pounds in hogsheads.

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ASSEMBLING, PACKING, AND STORING OF HORTICULTURAL CROPS

Problems and Objectives

Returns to producers and prices paid by consumers for horticultural crops are adversely affected by the use of inefficient marketing facilities, equipment, and methods. Better work methods, techniques, devices, operating procedures, equipment, and facilities are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing, and packing potatoes, citrus fruits, deciduous fruits, vegetables, nuts, and other horticultural crops. Such improvements at shipping points would increase the productivity of labor, prolong the storage life of the commodities, reduce bruises and injuries to these products, reduce marketing cost, expand consumption, and reflect greater returns to producers.

Major objectives of the research on methods, equipment, and facilities for horticultural crops are to:

1. Reduce labor and costs for handling, storing, and packing.

2. Protect products and provide optimum conditions for commercial storage.

3. Develop improved cooling, conditioning, and storage techniques and procedures.

Progress

Citrus Fruits

Improved degreening and cooling of Florida citrus fruit.--The manuscript, "Photoelectric Color Sorting of Citrus Fruits," was revised, and cleared by both the Transportation and Facilities Research Division and the Market Quality Research Division and submitted to the Information Division, ARS. Editorial changes and comments were reviewed and the manuscript has been resubmitted for publication.

Improved methods and equipment for handling and preparing citrus fruit for market.--A study was made on facility, equipment, and labor requirements and costs for precooling three million boxes of citrus fruit per season. The annual return and payback period were determined for substituting photoelectric equipment for grading labor to sort the fruit for surface defects. A new light chopper wheel was constructed and various solid state photosensitive devices were tested at different light levels. Samples of oranges were sent to a manufacturer of photoelectric sorters for defect sorting tests. Another manufacturer placed sorters in a citrus packinghouse and made tests on photoelectric defect sorting of oranges. Results of these tests were very favorable. Data from pilot setups of commercial units for automatic bagging of fruit in polyethylene film indicate the same output rates as last year.

Based on bags weighed, the average weight per bag must be 5.80 pounds with the lower limit not less than 5.25 pounds to allow for shrinkage and still remain within the 1% level of reliability. There is a possibility of saving by better control of bag weight. Further work on an experimental mechanism for automatic bagging of fruit in polyethylene mesh, to use material from a roll, resulted in workable actions to grip and open, raise for filling, make bottom closure, and cut below closure. Further work was done on the cost for semiautomatic versus automatic bag-filling operations. Further work was done on a manuscript covering methods and equipment for modernizing handling systems for Florida citrus fruit.

Deciduous Fruits and Tree Nuts

Improved equipment, techniques, and facilities for cooling apples and other fruits.--A test on hydrocooling Bartlett pears was performed to determine the effect on storage life and ripening response of pears as compared with rapid air cooling and slow air cooling. All fruit was packed in fiberboard boxes using polyethylene trays and liners and stored at 30° F. The hydrocooled fruit core temperature was reduced from 78° to 40° F. in 1/2 hour and to 32° F. in about 8 hours. The rapid air-cooling reduced the fruit temperature from 78° F. to 40° F. in 84 hours and to 32° F. in 145 hours. The slow air-cooling reduced the fruit temperature from 78° F. to 40° F. in 115 hours and to 32° F. in 160 hours. The Market Quality Research Division determined the relative chlorophyll content, firmness, soluble solids, and the titratable acidity of the pears. Pears from storage had very little difference in firmness between hydrocooled and "rapid" air cooled. The slow air-cooled pears were softer and softened more rapidly in the ripening room. Changes in color followed a similar pattern with a greater difference between hydrocooled (greener) and "rapid" air-cooled pears. Hydrocooled pears lost less moisture during cooling and storage than air-cooled pears. The weight loss in percentages were: Hydrocooled, 0.06; rapid air cooled, 0.93; and slow air cooled, 0.94. The cooling rate had no effect on soluble solids or titratable acidity. A manuscript covering this research was completed and submitted for review for publication.

Improved methods and equipment for precooling fruits and vegetables.--Research shows that forced-air precooling of peaches has a commercial potential as a means of conditioning the fruit prior to shipment. Some primary advantages of forced-air precooling over the existing method (hydrocooling) are increased sanitation, reduced water pollution, and more effective capability for gearing the conditioning treatment to the fruit needs with respect to maturity, initial field temperature, etc. Work now underway is aimed at the development of a system that combines hydrodumping with fungicidal treating (either heat treating or a chemical fungicide) and forced-air precooling to form an integral operation. Laboratory equipment was prepared to investigate the incidence of brown and rhizopus rot, desiccation and general deterioration (including softening and increased maturation) of peaches. Tests will provide for the forced-air precooling and simulated transit holding of select lots of peaches precooled and held at 40°, 50°, 60°, and 70° F. A revision

of Chapter 21, "Methods of Precooling Food," for the 1971 American Society of Heating, Refrigeration, and Air-Conditioning Engineers Guide and Data Book was drafted. A paper on the subject, "Principles and Equipment for Precooling Fruits and Vegetables," was written and presented at a symposium at the American Society of Heating, Refrigeration, and Air-Conditioning Engineers 1970 Semiannual Meeting.

Improved equipment, techniques, and facilities for storing apples and other fruits.--The manuscript, "Cold Storage for Apples and Pears," was completed and is now in review preparatory to publication. This manuscript revises and updates Circular No. 740. The manuscript covers in detail original research information from many papers and publications on the storage of apples and pears. It gives information on storage temperatures for tree fruits, storage diseases, refrigeration equipment, coil surface, air distribution, insulation requirements, humidity, air doors, calculations for heat loss and product load, and controlled atmosphere storages. A pear clinic held at Medford, Oregon, determined that most ripening trouble experienced by the pear industry was due to improper storage conditions such as improper stacking, air distribution, and insufficient cooling capacity. Instructions were given on the installation of thermocouples to aid in determining storage temperatures of stored pears. A study of controlled atmosphere storage construction and operation continues.

Improved equipment and procedures for sorting and sizing apples before storage.--The brush fruit grader was moved to and installed in the packinghouse of another cooperator. Additional grade separations were made possible, and the grader was provided its own dumper. This arrangement permitted full-scale commercial runs over the entire apple packing season. Data were collected for an objective evaluation of this experimental grader. Only Golden Delicious apples were used. These were all wrapped and tray packed into polyethylene-lined cartons. Once initial adjustments were made, the grader ran well mechanically even at a sustained maximum translation rate of 36 feet per minute. However, sorters and packers were unable to maintain this fast pace. During peak production of 85 pallet boxes (each holding 24 bu.) per day (7-1/2 hours) the crew consisted of 10 sorters, 14 packers, and one man tending the dumper. Sorters had excellent visibility of the apples. Fruit was well polished by the brushes. Bruising to apples that would change the grade occurred only on some very large apples as they were released from the sizing section and rolled onto take-away belts. This small number of apples was not significant. Sizing remained a problem as 7.5% of the apples were delivered undersized and 46.7% oversized. Of the apples missized, 86% was off by only one size. Because of this, shunts were removed and the apples were delivered to packers in mixed sizes. Even with the added job of sizing, packers averaged about 100 cartons per day, with some reaching 117, which is slightly below the normal rate of packing 120 to 125 boxes per day.

Designing and testing a hydrohandling system for prestorage sorting and sizing of apples.--The final contract report, "Design and Evaluation of a Hydrohandling System for Apples Fruits," was reviewed further and some

additional editing was done. Several technical discussions were held with the personnel who conducted this contract research.

Improved methods and equipment for handling and packing tree fruits in the Pacific Northwest.--A study was conducted to determine if and how the weight-to-diameter ratio of Red and Golden Delicious apples changed over time. This change has a direct bearing on both the sizing and packing operations. The weight and diameter of each apple in samples picked 135 days after full bloom was measured. The apples then were placed in cold storage and measured again at monthly intervals. Half of the Red Delicious apples were stored in open boxes and half in polyethylene-lined boxes. All Golden Delicious apples were stored in polyethylene-lined boxes. Weight and diameter of small and medium size apples decreased at approximately the same rate for both varieties, but weight loss became noticeably greater for apples of 3-inch diameter and larger. Variation in each lot was greater than expected. Only 70% of the Red Delicious and 76% of the Golden Delicious apples remained within the same size group based on both fruit weight and diameter. This change contributes to the difficulty in achieving precise and uniform weight within packed cartons. Each of the three lots had its own distinctive weight-to-diameter curve. Red Delicious apples stored in open boxes lost an average of 4.2 grams per apple, or 2.6%, during a 6-month storage period; those apples stored in polyethylene-lined boxes lost only 1.7 grams, or 1.0%. This difference in weight loss may be great enough to warrant storing both Red and Golden Delicious apples in polyethylene-lined containers. Some further work was done on the manuscript, "Electronic Color Sorting of Apples."

Improved methods and equipment for handling and preparing peaches for market.--Work on developing a pallet box hydrodumper for peaches that will be economically adaptable to low-volume (200-400 bu. per hour) packinghouse operations was continued. Construction of the prototype hydrodumper, which incorporates a new simplified dumping principle, was completed and tested. The dumping mechanism consists of a cage suspended from a monorail by a chain hoist for holding and lifting boxes and a fixed bar mounted above the end of the tank. Hooks on one end of the cage are engaged with a fixed bar on a tank. As the cage is lowered, the weight of the box rotates it and the peaches are poured into a tank of circulating water. Tests determined the location of the pivot point with respect to the water level in the tank for the optimum removal of the fruit and the maintenance of quality. Optimum water flow rates and distribution patterns were determined. It was found that peaches could be dumped at a rate of 335 bushels per hour with the pivot point 12 inches above the water level. The results showed that the equipment could be improved by reducing the tank water depth from 6 ft. to 2 ft. The equipment was modified and preliminary tests with peaches indicate commercial feasibility.

Improved methods and equipment for handling and preparing pecans for market.--Work to develop guidelines for conditioning pecans to improve shelling efficiency, measured by number of halves obtained, was continued. The effects of conditioning treatment variables--soak time, water temperature, and

hold time between soaking and cracking--on shell moisture content, kernel moisture content, and percent halves obtained in shelling pecans were determined. A factorial experiment included four water temperatures (35°, 70°, 105°, and 140° F.), three soak times (1, 3, and 5 hrs.), and five hold times (0, 6, 12, 18, and 24 hrs.). A prediction equation was developed by multiple regression analysis. It was found that kernels from pecans soaked in 140° F. water not only turned an objectionable dark tan in color after shelling but also tasted bitter. This was attributed to the absorption by the kernels of soluble tannins from the inner shell. The shell moisture content, kernel moisture content, and percent halves obtained were calculated using the prediction equations for conditioning treatments selected as having commercial feasibility. The results will be used to develop industry guidelines for commercially conditioning pecans to improve cracking and shelling efficiency. A paper on "Conditioning Pecans for Increased Shelling Efficiency" was prepared for presentation at the Summer Meeting of the American Society of Agricultural Engineers.

Potatoes

Improved methods and equipment for handling and preparing fall crop potatoes.--The work on systems analysis of potato packinghouses is on schedule. Preliminary data were obtained, and modeling techniques were evaluated. A unit-flow network analysis was rejected as too restrictive and requiring many changes to represent division of product flow. Therefore, the method was switched to a General Purpose Simulation System with the assistance of the North Dakota State University Industrial Engineering Department. A General Purpose Simulation System provides the flexibility and realism required. A preliminary model and computer program was developed. Parameters were established for checking program and model validation. Computer simulation shows great potential in packinghouse research as new methods and equipment can be examined for total system effects quickly and efficiently. The model, when perfected, should be convertible to study similar processes with other commodities. Evaluation of circular layouts for potato storages showed several advantages, primarily in materials handling. We cooperated with the University of Minnesota Agricultural Engineering Department in setting up a project to design a loader for hopper-type rail cars. A semiautomatic bucket-type loader has been proposed. We assisted the North Dakota State University Agricultural Engineering Department in setting up a project to examine carbon monoxide buildup in potato storages from use of powered bulk scoops. Two manuscripts were prepared and submitted for publication.

Impact on packinghouse operations and costs of cleaning and sizing fall-crop potatoes before storage.--All dimensional, weight, and volume data on fall crop potatoes were assembled in a specified format and forwarded to Biometrical Services Staff, ARS, for detailed computer analysis for verification of preliminary field station calculations. There are no conclusive results from the small portion of analysis that has been returned. Work was done on the manuscript, "Feasibility of Sizing Potatoes into Storage."

Improved design for above-ground potato storages in the fall-crop area.--We consulted with extension agricultural engineers on the remodeling of 25 existing potato storages, and discussed with growers, contractors, and equipment suppliers designs for over 40 new potato storages. We also prepared and published an extension service bulletin containing design information for modifying ventilation systems in older potato storages, and participated in an extension sponsored potato storage workshop covering mechanical and structural components and environmental factors and their control. Some editing was done on the manuscript, "Fall-Crop Storage and Handling of White Potatoes." The manuscript, "Bin Fronts for Potato Storages," was edited and forwarded for publication.

Providing optimum conditions for the storage of potatoes for processing.--Observations in a Market Quality Research Division cooperative storage survey indicate that many problems in storing processing potatoes are due to potato quality and management practices. Improper ventilation, vapor barrier, and insulation applications also are causing problems. Results of the Market Quality Research Division's cooperative bulk shipment study indicate that new bulk mechanical cars maintain more uniform environmental conditions than old standard refrigerator cars. Some air distribution problems may occur in the mechanical cars. Small centrifugal blowers and square edged orifice combinations have been calibrated to provide airflow rates of 0.5 to 1.5 cubic feet per minute for small environmental chambers. Suitable resistance heaters and controls have been obtained for these chambers.

Methods, equipment, and facility improvement for handling and preparing Maine potatoes for market.--A pilot test of potato bin pressures was initiated to develop techniques and procedures prior to conducting full scale tests using strain gage pressure panels. The panels were installed ten high in the front of a bin 10 feet wide by 12 feet long in which the potatoes were piled 12 feet high. Strain readings were taken daily during the storage period. Data from these tests indicate that the maximum lateral pressure of over 100 lbs./sq. ft. is higher than reported by previous researchers. Although attempts to secure packing line equipment capacity data from manufacturers were not completely satisfactory, the information obtained supplemented previously collected data on determining practical maximum capacities for this equipment. Data were collected for capacities and outputs of different size bulk scoops. The collection of data on packing washed Russet Burbanks in count-boxes is in process. A study on cross-flow air circulation was conducted in a below ground type storage and an above ground storage. The bin width was 20 ft. in the direction of airflow. Cross-flow circulation was determined to be feasible. Potato fluming trials were conducted with 90°, 60°, and 45° flume intersection angles. The influence on bruising of potatoes during fluming was evaluated when: (1) Warm water was used as the fluming media and (2) potatoes were warmed prior to fluming. Warm water was not effective in preventing damage. It was necessary to warm the tubers to prevent bruising. A manuscript has been developed on hydraulic handling of potatoes.

Improved methods, equipment, and layouts for preparing spring-crop potatoes for market.--Changes in industry methods and practices continue toward greater mechanization. More semiautomatic machines are used for filling 50- and 100-pound burlap and paper bags in conjunction with sewing machines for closing burlap bags and wire tieing machines for closing paper bags. Information obtained on developments in commercial equipment indicates the possibility of a greater degree of mechanization in the filling of large bags through change in the equipment to provide mechanical hanging or placing of the bag for filling instead of manual performance of this function by one worker as required with presently used machines. Also, there is a possibility of reducing one worker by machine moving the filled bag, after release from the filling head, into the closing machine. Further study is needed on the feasibility of using newer bag-filling machines. The most efficient combinations of methods, equipment, and facilities for packinghouses in the future is in a state of flux because of the progressive shift from bag to bulk shipments and other changes mentioned.

Designing and testing hydraulic handling systems for potatoes, sugar beets, and other crops.--Data from tests on pumping potatoes in water obtained with the closed pipe system were analyzed. Design information for pipelining water-potato mixtures then was developed. In addition, solutions (FORTRAN programs) were developed for predicting head losses for uniform- and mixed-size particles when moved vertically in any fluid in a closed system. Further trials with flume intersections were carried out. Preliminary layout plans were prepared. Tests were conducted with a drop inlet into a part-full round section transport. Economic analysis of hydraulic handling was made and a comparison with other systems initiated. The developing of design criteria for hydraulic handling systems was begun.

Vegetables

Improved methods, equipment, and facilities for handling and preparing Florida vegetables for market.--Tests were continued with the weight sizer for vine-ripened tomatoes. With fruit weighing in the 250-gram range, sizing accuracy was 26 grams at rates up to 315 fruit per minute. Accuracy was reduced to 44 grams when the sizing rate was increased to 350 fruit per minute. Data were gathered on cabbage handling and sizing operations. Packing times ranged from 0.8 to 1.3 minutes per crate. Semiautomatic equipment for packing carrots was installed in a packinghouse and tests begun. Production rates of 1,000 packages per hour were attained during short runs. Studies were begun on handling and hydrocooling vegetables in unit loads. The unit-load system can reduce the direct labor of 52 workers in the conventional system to 23 workers at a handling rate of 2,000 crates per hour. Values from spectral reflectance curves on tomatoes ranging in color from dark red to dark green indicated that the ratio of reflectance at 680 nanometers to that at 550 was favorable for separation of tomato colors. Data from forced-air precooling tests indicated a mass average temperature reduction of 38 degrees for carrots and 45 degrees for bell peppers after 20 minutes of cooling with air at 30 degrees and 200 feet per minute. Equipment was obtained to set up walk-in

rooms having close control of temperature and humidity. Additional editing was done on two manuscripts on precooling celery and color sorting tomatoes.

Designing and testing principles for mechanical celery stripping.--A commercial model celery butt trimmer, tested on a pilot operation basis last year, was installed in a packinghouse and used to remove outer unmarketable petioles under commercial conditions. In one test, petioles were removed from a group of celery stalks by machine and another group of stalks was hand stripped. In another test, the force required to remove a petiole from both machine and hand-stripped stalks was measured. With both treatments the width of the petiole at its point of attachment to the stalk was measured. Analysis of the data showed no statistical difference between the two methods of petiole removal, either in reduction of stalk weight or loosening of petioles remaining on the stalk after trimming. Preliminary labor requirements were obtained with cooperator personnel performing the machine removal operation. With hand stripping, production rates ranged from 12 stalks per minute when two or three petioles per stalk were removed downward to about seven stalks per minute when five petioles were removed. The machine removal rate remained fairly constant at 12 stalks per minute.

Improved methods and equipment for hydrocooling unit loads of packed vegetables.--Six hydrocooling test runs on pallet loads of sweet corn in wire-bound crates, four layers high, eight crates per layer, yielded average load half-cooling times of 0.31 hr. for a load immersed in water circulating at 55 gallons per minute (g.p.m.); 0.43 hr. with five nozzles spraying downward at 90 g.p.m., and 0.52 hr. with five nozzles (two on each side and one on top) producing an envelope spray at 90 g.p.m. Tests showed the immersion method was superior, followed by the downward spray. Seven test runs on four-layer stacks, to investigate the effect of circulating air in combination with water spray, yielded half-cooling times of 0.46 hr. for coarse spray with air, and 0.55 hr. without air, at 100 g.p.m.; and 0.49 hr. for fine spray with air, and 0.62 hr. without air, at 65 g.p.m. Tests showed that a fine spray with the air method permits reducing water by one-third without affecting cooling. Two test runs with celery and two with escarole indicate similar results except that much faster cooling was obtained. Tests with pallet loads of sweet corn five layers high yielded half-cooling times of 0.68 hr. for air and fine spray at 48 g.p.m., 0.68 hr. for air and coarse spray at 100 g.p.m., and 0.58 hr. for the conventional flood pan at 200 g.p.m.

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ASSEMBLING, SLAUGHTERING, STORING, AND PROCESSING OF LIVESTOCK, MEAT, DAIRY, AND WOOL

Problems and Objectives

Much of the huge animal and animal product industry is operating in obsolete facilities using costly manual methods. Engineering research techniques were developed for improving work methods, devices, operating procedures, equipment--including automated systems--and facility layouts. Application of these techniques could reduce marketing costs as much as $50 million per year.

Major objectives of this research are to:

1. Minimize facility cost and increase productivity by developing efficient layouts for livestock markets, meat plants, and dairy product plants.

2. Reduce marketing costs by developing improved operating procedures and more efficient utilization of labor.

3. Reduce marketing costs by designing, constructing, and testing new or improved equipment that will replace expensive manual methods.

4. Minimize operating costs by developing techniques for adapting automated procedures to livestock, meat, and dairy marketing.

Progress

Dairy

Increasing efficiency through automation in multipurpose fluid milk plants.--Evaluation of the automated equipment installed in the University of Missouri (Columbia) dairy plant was continued. A comparison of labor utilization by each product for the nonautomated and automated plant was made to determine the effect of automation on the individual products. The plate flow unit was redesigned to: (1) Allow for temperature changes in the cleaning solution, (2) permit installation of a flow meter with a digital readout unit, (3) permit the use of tap instead of distilled water, and (4) permit automated control of the experiment. The Agricultural Engineering Department constructed a plastic laboratory with improved environmental control which makes it possible to obtain more accurate data. The rate of removal of raw whole milk residue from a stainless steel surface, using the calcium analysis method, was obtained for the rinse and cleaning cycles at 95° F. Preliminary tests indicate no difference between cleaning at 95° and 145° F. A pipe flow unit was designed, constructed, and used to determine the rate of removal of milk solids from an enclosed stainless steel pipe by conductivity for flow rates of 15, 30, and 45 gallons per minute, and for temperatures of 95° and 125° F.

Approximately 90 percent of the residue was removed in the first 2 seconds of flow. Preliminary tests were started to develop a method to determine the amount of residual fat on a stainless steel surface. Preliminary studies were made to determine the parameters which affect accurate fill control for packaging milk and milk products in various sizes of containers.

Increasing efficiency through automation in manufactured dairy products plants.--Several trips were made to dairy plants which process dried milk. Studies were made to determine the immediate needs of these plants with regard to engineering problems. To meet these needs, work on preparing preliminary plant layouts was started. The purpose of these improved layouts is to provide guidelines for plant managers and owners who are considering remodeling old facilities or building new facilities to increase the efficiency of their operations. This project, initiated during the fiscal year, has not progressed to the point where there are significant accomplishments.

Livestock

Improved methods and computer handling of sales data on livestock markets.--The Cooperator on this research, Computer Research Center, University of Missouri, has converted the original machine language program for processing a livestock market's sales data on an IBM model 1130 computer system to COBOL (Common Business Oriented Language). The testing of the program, using remote input and output terminals and actual sales data, was delayed due to problems encountered in securing a static-free telephone line for use in transmitting sales data. Some testing was done near the end of the report year using synthetic sales data on a computer located at the University of Missouri. Several markets have indicated an interest in the processing of their sales transactions using a computer. They are interested in the COBOL program since it is easier to understand by non-technically trained people. Two markets have adapted the original machine language program to fit their operations and have installed IBM 1130 computer systems to process their sales transactions. The installation of the original machine language program has been used satisfactorily on the Central Missouri Livestock Market, Mexico, Missouri, for more than 2 years.

Improved layouts, equipment, and operating criteria for livestock auction markets.--A draft of a manuscript updating the Division's previous publications on auction markets has been completed. The largest cost item in operating a livestock auction market is labor. The layout of the market is important to provide a free flow of livestock without interruption, as this directly affects labor usage. The manuscript covers flow of livestock from unloading docks to holding pens and all phases of handling before and after sales from holding pens to loading-out docks. Some of the other items covered are sorting, tagging, or other means of identification of livestock, weighing, location of scales, and holding pens before and after the sale. Local market practices that influence market layout are described and evaluated. These practices vary from one geographical location to another. They require that certain functions be performed at a different place or time in the normal cycle of selling livestock.

Improved methods, equipment, and facilities for handling waste material from livestock markets and feedlots.--On this project, approved during the fiscal year, progress was limited to determining how the livestock marketing industry is disposing of its animal waste materials, current problems in disposing of this waste material, and current problems associated with runoff from holding pens and other uncovered areas. Some of the current disposal methods include dehydration, landfill, spreading on land, and lagooning. In dehydration, some of the existing problems are air pollution, handling required to stockpile and turn, runoff from stockpiles, operation of dehydrators, and excessive power requirements of dehydrators. Landfilling problems include handling of waste material, possible pollution of underground water, and odor. Spreading on land is not practical in some areas because livestock producers are afraid of disease organisms and because grain producers are concerned with noxious weeds. Where spreading on land is practiced, because the waste material is spread only in late fall and during the spring, the waste material must be stockpiled. Hauling and spreading involves the use of large trucks which can traverse the land only when it is dry enough to support the trucks. Runoff from non-covered pens and other non-covered facilities is entering natural waterways and streams. This runoff is considered a pollutant by many State water pollution boards. The amount of the various pollutants in this runoff must be determined if methods of disposal are to be developed.

Meat

Improved methods, equipment, and facilities for frozen portion control hotel supply houses.--The manuscript covering research in hotel and restaurant meat supply houses that prepare, package, and freeze the meat products and deliver orders from inventory was revised to include recently introduced meat fabrication equipment and to update the cost data for both labor and equipment. The Information Division has cleared the manuscript.

Improved methods and equipment for handling and processing "hot" pork products.--Processing of 225 pork carcasses directly from the kill floor was completed at Hormel and Company, Fremont, Nebraska. The commercial test period was completed with all phases considered satisfactory. The ham, loin, and butt molds used in the commercial tests performed satisfactorily and showed considerable promise for large-scale commercial use. Data collected during the commercial test period has been programed for computer analysis. Computerized data includes: (1) Microbial counts of fresh and cured hams and loins; (2) color stability studies covering all major cuts; (3) chemical data on fresh and cured hams and sausage products; and (4) temperature, humidity, air velocity, and other data concerned with the mechanical performance of the continuous flow chill cabinet. Following completion of the in-plant studies, the chill cabinet was returned to the Meat Laboratory, University of Nebraska, at Lincoln. The computer analysis has been completed and the cooperator is preparing his final report covering the results of this research.

Improved methods, equipment, and facilities for inedible animal by-products rendering plants.--Results of engineering studies in rendering plants

indicate that improved layouts, work methods, and equipment can reduce operating costs. These analyses also indicate that increasing operating efficiency, without taking into account the problem of salmonella contamination in rendering plants, would not provide the guidelines and assistance needed by this industry. Case studies were completed in six cooperating Oklahoma rendering plants to obtain environmental data for evaluating total bacteria count causes and effects in in-plant operations and product contamination relationships to environmental factors. Some common factors found to be contributing to the high incidence of salmonella in inedible rendering plants are: (1) Excessively long conveyors were used after the cooking process, which allowed the product to cool and become recontaminated, (2) uncovered conveyors allowed recontamination of cooked material, (3) crossover conveyors permitted raw material to pass directly over cooked material, (4) poor operating methods allowed the product to remain in perc pans too long, (5) almost complete lack of concern by the rendering industry, (6) cross traffic between departments permitted mixing of cooked and raw material, and (7) inadequate grinding of raw material prior to cooking resulted in incomplete salmonella kill in the larger pieces.

Improved methods, equipment, and facilities for meat packing plant operations.--Thirteen plants in nine States were visited to obtain time-study data of on-the-rail beef kills in the range of 20-45 head of beef cattle per hour in order to update MRR-657, "Cattle Killing-Floor Systems and Layouts." These time studies were individually analyzed for problem areas, bottlenecks, and productivity, and were compared to standard times for the industry. Results of the individual studies were made available to plant managers and suggestions were made to each for improving his operation. Benefits for one packer permitted him to increase the line output by 15,000 head per year at the nominal expense of purchasing a skil-saw and the employment of a utility worker. Studies at another packing plant provided information for improvements which permitted the packer to increase his output by five head per hour by adding a hide-pulling machine. Further studies at this plant indicate that the kill rate could be increased another five head through proper work element allocation. Other work included designing a new meat supply unit which opened recently on the Oklahoma State University campus and designing a meat laboratory to be built by the Kellogg, Rockefeller, and Ford Foundations as a part of the new University of Tropical Agriculture at Cali, Colombia, South America.

Layouts and operating criteria for small locker-type meat packing plants.--Research on this project was initiated during the report year; thus, little progress can be reported at this time. Contacts have been made with industry groups and a limited number of plants have been visited. Several requests for assistance in remodeling plants to meet the requirements of the Wholesome Meat Act have been received.

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Dairy

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Meat

Hammons, D. R., and Hale, A. P. Reference Reports for Salmonella Program Inspectors--Rendering Animal and Poultry Byproducts. ARS 91-77, Sept. 1969.

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Problems and Objectives

Processing poultry meat items has become a highly complex food manufacturing process. Similarly, the processing, grading, and packing of fine quality eggs and egg products have required drastic changes in the facilities, equipment, and work methods. It is estimated that preparing these commodities for market costs the industry approximately $1.5 billion annually. Although industry is to be commended for its efforts in meeting the demand for these food items, little has been done in developing guidelines for new plants or in solving plant production problems involving the integration of new processes with large-scale operations that frequently continue to use outmoded methods, facilities, and equipment contributing to the high cost. By using guidelines for improving facilities, equipment, and work methods being developed by the Division through application of engineering research techniques, it is estimated that the poultry industry will be able to reduce the processing costs 1 percent, or approximately $15 million annually.

Major objectives in this area of research are to:

1. Reduce construction costs and increase plant capacity by developing basic guidelines for efficient plant layouts and structural designs for poultry processing and egg grading and packing plants.

2. Decrease processing costs by more efficient labor utilization through an engineering analysis of work methods and the development of improvements to implement new or existing processing facilities and equipment.

3. Fully utilize technological advances in food processing by designing, constructing, and testing new or improved equipment that will reduce marketing costs while minimizing hazards to product quality.

Progress

Eggs and Egg Products

Improved methods, techniques, and equipment for commercial egg grading and packing plants.--Research to determine the impact shocks that cause breakage during commercial processing was continued. An acrylic plastic material was fabricated to simulate the surface shape of a hen egg. A cavity was machined inside to hold a miniature accelerometer and transmitter system. The system was designed to measure accurately shocks to which an egg is subjected as it moves through mechanized egg grading and packing equipment. The signal range of the transmitter which identified the impact (of the instrumented egg) at which a normal hen egg will break was determined by the

calibrated pendulum technique. Preliminary laboratory tests were successful in that frequency modulation signals were transmitted and received when impacts within the breakage range occurred. Factors, such as transmitter design and consistency in signal replication require further study and refinement. The use of this technique appears feasible in isolating breakage-causing factors by egg grading and packing equipment to serve as a basis of improved designs.

Poultry and Poultry Products

Improved methods and equipment for handling live chickens by commercial processing plants.--Studies of methods, equipment, and facilities for loading coops of live poultry (broilers) by powered lift trucks were completed. The labor and equipment requirements determined for these methods were compared with those for manual handling. A draft of a report on the results was prepared. Based on test methods that successfully detected unsatisfactory live bird handling procedures, a guide for the development of a quality control program is being prepared to assist processors in reducing downgrade damage such as broken bones, skin tears, and bruises. Time studies with stopwatches and motion pictures were made of live poultry receiving operations at the docks of commercial processing facilities in Georgia, Alabama, and Florida. Data from these studies will be analyzed and used as a basis for comparison with improved methods, equipment, and facilities now being developed. A prototype of a coop unstacking tower for mechanizing live poultry unloading operations has been constructed and laboratory tested prior to installation in a commercial facility. This device is designed to receive stacks of coops, unstack, and mechanically dispense them to the processing plant slaughter line loading station. This equipment will eliminate most of the labor required to unload coops of live poultry and will reduce bruise damage caused by rough handling.

Improved equipment and techniques for slaughtering and defeathering chickens in commercial plants.--Evaluation of methods and equipment currently being used to slaughter and defeather broiler class chickens in commercial processing plants was continued. The effect of post-rigor struggle as it relates to wing damage and bruising was observed as were the effects of post-slaughter stunning on feather release, bleeding, and post-rigor struggle. Preliminary findings dictate that the research effort should concentrate on modifying present methods and equipment to reduce product damage such as bone breakage and bruising and minimize the hazard of bacteriological contamination. Modifications also will be directed toward reducing the biological load carried off in the plant waste water.

Improved work methods and equipment for cutting up chickens in commercial processing plants.--Tests under commercial operating conditions were completed for two machines, one for cutting broilers into five pieces and one for splitting broilers into halves or quarters. Modifications that were made to the feed mechanism increased cutting accuracy so that more "A" grade breast parts were obtained from the machines than from conventional cutting methods. Production rates of 40 birds-per-minute were achieved. Final modification

of a 9-cut machine was completed and tested in the laboratory and under commercial processing plant operating conditions. The initial plant tests were satisfactory with cuts being made as accurately as conventional methods. Production rates of up to 15 birds-per-minute were attained under commercial operating conditions with potential labor savings of more than 50 percent. Conventional cutting methods and equipment were analyzed for comparison with machine operations. Patent applications were processed for all equipment developed.

Improved equipment and operating methods for poultry processing to reduce water requirements.--Investigations of water use rates were continued in selected case study poultry (broiler) processing plants to determine the quantity of water used for various processes, pieces of equipment, and overall plant operation. Measuring devices and pressure gauges were installed on water supply lines to bird washers in three case study plants. Basic data collected on bird washers currently in use include bacteria counts before and after washing, water pickup in bird washer, and volume of water used at various pressure levels. An experimental bird washer that allows an infinite number of nozzle positions and pressure adjustments was designed and constructed. Interchanging various types and sizes of nozzles made possible the study of the effects of water pressure, water flow rates, and nozzle types and position on bacteria removal and water pickup of an eviscerated broiler carcass.

Improved methods, equipment, and facilities for eviscerating turkeys in processing plants.-- Time values for all phases of the turkey eviscerating operation have been established through application of motion time measurement (MTM) method analysis. After confirmation of time values using a constant speed motion picture camera, minor adjustments were made to MTM values, then labor requirements determined. Analysis shows a considerable amount of waiting time by some workers. In order to reduce this inefficiency, an optimum crew balance was synthesized, using MTM time values. A publication is being prepared that sets forth the time required for each work element, the optimum line speed, and the number of workers needed for an efficient conventional eviscerating line operation. The possibility of changing work element structure and sequence of operations is being investigated. The modifications of equipment and work station layouts that would be necessitated by such changes are being studied.

Improved methods and equipment and facilities for cutting up and deboning turkeys.--Yield data for manual vs. mechanized turkey boning is in process of being computerized for statistical analysis to be used in a final report for publication.

Improved methods, equipment, and facilities for cutting up and deboning fowl.--Research to improve raw fowl deboning was initiated during this fiscal year. Preliminary investigations indicate that very few commercial fowl processors are now engaged in large-scale raw deboning operations. A number of plants on the West Coast were contacted for consideration as sites for testing experimental equipment. A plant in Douglas, Georgia, was selected as

a "typical" manual raw boning operation comparison base if none is found on the West Coast. Investigation shows the most popular cuts and parts of fowl being sought in markets include the skin, boned breast meat, boned leg meat, fat, and wings (not boned). Scrap meat on the remaining carcass is removed by a boning machine that yields a comminuted meat. Equipment such as skinning machines and power cutters was examined for design features that merit consideration for implementing mechanized boning line components. A laboratory scale work station for deboning fowl manually was designed for the methods analysis studies.

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Poultry

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CONSUMER PACKAGES AND SHIPPING CONTAINERS

Problems and Objectives

The total volume of shipping containers and packaging materials used in 1969 was $19.5 billion. The total packaging bill, including related services such as contract packaging and in-plant packaging operations, was in excess of $32 billion in 1969. The food and beverage market is the largest user of packaging, accounting for an estimated 60 percent of the total.[1/]

Without efficient packaging, it would be difficult to move perishable products from fruit, vegetable, dairy, and poultry producing farms through our intricate marketing system to 200 million consumers. Research is needed to determine the packaging requirements of agricultural products and to fit the properties and functions of available and newly developed packaging materials such as plastic films and expanded polystyrene foam to these requirements. Packaging benefits consumers by protecting the products against mechanical damage and insects, maintaining quality, providing convenience in selection and preparation, preventing pilfering, providing cleanliness and sanitation, conserving nutrients, providing eye appeal and, perhaps most important, holding down the cost of marketing foods.

Although the broad goals of research on packaging and containers are to (1) expand markets, (2) help increase farm net returns, and (3) give consumers better service and quality products at most favorable prices, the specific objectives of packaging research projects now underway are to:

1. Reduce costs of marketing.
2. Develop standard sizes of shipping containers.
3. Develop lighter weight packaging.
4. Protect consumer health by sanitary packaging.
5. Provide more services and conveniences to retail store patrons and institutional users.
6. Reduce spoilage and nutritional losses.
7. Help maintain and strengthen the competitive position of U.S. exports.

1/ U.S. Industrial Outlook, 1970, U.S. Department of Commerce, Washington, D.C.

Packaging researcher explains how packaging research benefits consumers to Mrs. Virginia H. Knauer, Special Assistant to the President for Consumer Affairs, and Dr. George W. Irving, Jr., Administrator, ARS.

8. Develop new foreign markets.

9. Increase the income of producers.

Progress

Improved Packaging for Domestic Markets

Standardization of shipping containers for fresh fruits and vegetables.--A total of 371 different size (varying 1/4 inch or less in any one dimension) shipping containers were found being used for marketing fresh fruits and vegetables in the cities of New York and Los Angeles. Only 64 of the 371 different size shipping containers were found with suitable dimensions for efficient palletizing (covering 90 percent or more of the surface area) on a 48- by 40-inch pallet. A 48- by 40-inch pallet is the standard size pallet adopted by the Grocery Manufacturers Association of America. Only 51 of the 371 different size containers found in this survey can be efficiently palletized on the 120- by 100-cm. pallet which has been adopted by the International Standards Organization and the Organization for Economic Cooperation and Development. The efficiency with which the 371 different containers fit other size pallets is being analyzed.

Shipping containers for western cherries.--Fiberboard and expanded polystyrene foam boxes that were test marketed in 1969 need some changes in design before they can be used widely for marketing fresh western cherries,

Cherries in new shipping containers on display for sale in auction market: Box on the left is polystyrene foam, box in the center is corrugated fiberboard, and box on the right is the conventially used wood box.

but they offer promise of reducing the costs of packing and shipping cherries. The costs of packaging and palletizing materials, direct labor to pack and palletize, and charges for air transport to ship 18 pounds of California cherries from San Francisco to New York amounted to $2.71 for cherries shipped in wood boxes, $2.42 for those in fiberboard boxes, and $2.44 for those in polystyrene foam boxes. The costs of shipping 20 pounds of Washington cherries by rail from the Yakima area to eastern markets were $1.28 for the wood box and $1.11 for both the fiberboard box and the polystyrene foam box. The lower cost of packaging materials and the reduced tare weight, which resulted in lower transport charges, were the principal factors accounting for the lower costs of using fiberboard and polystyrene boxes.

For the air and rail shipments, 11.1 percent of the cherries were bruised in the wood box, 16.4 percent in the fiberboard box, and 8.4 percent in the expanded polystyrene foam box on arrival at eastern markets. To cool cherries from 72° F. to 56° F., required 24 hours when the cherries were packed in fiberboard boxes, 11 hours in wood boxes, and 7 hours in polystyrene foam boxes.

If 25 percent of the western cherry crop is shipped by airfreight and 75 percent by rail, about $530,000 can be saved annually if the cherries are packed in either fiberboard boxes or polystyrene boxes instead of in wood boxes.

Improved packaging of tomato transplants.--The appearance and temperatures of tomato transplants packed in wirebound boxes with peat moss and kraft paper wrapped around the roots and of tomato transplants packed bare rooted (without peat moss or kraft paper) and test shipped from south Georgia to Ohio were substantially the same. Two additional treatments were included in the test: (1) bare-rooted plants with a wax-based transpiration-suppressant spray applied to the foliage before the harvest and (2) bare-rooted plants with wax-based transpiration-suppressant dip applied after harvest.

The percentage of survival, over 12 days' storage, of bare-rooted plants and of bare-rooted plants with transpiration-suppressant spray applied, was significantly higher than for the plants standard packed and bare rooted with transpiration-suppressant dip. There was no significant difference in the survival of plants stored for 0 and 6 days. However, the survival of the plants stored for 0 and 6 days was significantly higher than for those stored for 12 days. The survival of the bare-rooted plants stored for 12 days, with and without transpiration-suppressant spray, was not significantly different from the survival of those stored for 0 and 6 days. The marketable yield of tomatoes corresponded with the percentage of survival.

Improved packaging of fresh poultry.--The total costs of packaging materials, packing, loading and unloading labor, coolant, and transport per 100 pounds of poultry shipped were as follows: (1) Water ice-packed poultry - $1.59 in fiberboard boxes and $1.55 in polystyrene boxes and (2) dry ice-

packed poultry - $1.42 in fiberboard boxes and $1.52 in polystyrene boxes. The costs for dry ice-packed poultry are based on using 14 ounces of dry ice snow per box. For each additional pound of dry ice snow used per box, the cost per 100 pounds of poultry shipped would increase by 7.7 cents. The percentage weight loss of poultry from processing plant to receiver's warehouse was significantly higher for dry ice-packed poultry (6.3 percent) than for water ice-packed poultry (5.5 percent). The average temperature of poultry on arrival was significantly higher for dry ice-packed poultry than for water ice-packed poultry (33° F.).

Warehouse receivers and retail receivers preferred the dry ice-packed poultry because the boxes were lighter in weight, not as messy, easier to handle and appeared more sanitary. Carcass percentage weight loss of poultry stored at 33° F. was not significantly different in fiberboard boxes with water ice or dry ice. However, weight loss of poultry in polystyrene boxes with dry ice was significantly higher than weight loss of poultry in fiberboard boxes with water ice or dry ice. Weight loss of poultry at 40° F. was significantly higher in both types of boxes when packed with dry ice than when packed with water ice.

Standardization of shipping containers for meat.--This project was initiated in March 1970. It provides for research to improve the efficiency of marketing meat and meat products by studying the types and sizes of shipping containers in use, product and container damage, and the development of recommended standard size shipping containers. A survey of the type and size of containers, product and container damage has been completed in two chain-store receiving warehouses.

Dehydration of packaged frozen pork.--This project to study the effects of packaging and handling of frozen pork during transport and storage on weight losses was initiated in March 1970. A survey has been made in eight refrigerated warehouses to determine the most common methods of handling, packaging, and storing frozen pork bellies and hams to provide information to design and experiment to determine the effects of various packaging materials and handling practices on weight losses during storage.

Improved Packaging for Export Markets

Improved packaging of celery exported to Europe.--Two van container and one break-bulk test shipments of Florida celery packed in 50- by 40- cm. fiberboard boxes and in conventional wirebound crates were made to Europe. Some of the celery was wrapped in polyethylene bags and some was not wrapped. The 50- by 40-cm. experimental fiberboard box is one half the size of the conventional wirebound crate. In one van container test shipment, the boxes were palletized on a standard 120- by 100-cm. pallet; in the other shipment, the boxes were hand stacked. The condition of the celery and the containers in the van container shipments upon arrival in Europe was good. The wrapped celery had less dehydration than the unwrapped celery. Both the pallet load of boxes and the hand-stacked load of boxes in the van container shipments

arrived in good condition, showing very little damage. In the van container shipments, some of the boxes were assembled and closed with staples and some were assembled and closed with hot melt glue. The boxes closed with staples caused more damage to the celery than the boxes closed with glue. Fifty percent of the fiberboard boxes in the break-bulk shipment showed considerable damage from crushing.

Improved packaging of apples exported to Europe.--Packing and shipping apples from Oregon and Washington to Europe in 800-pound, 4-cell bin pallet boxes cost $2.47 per 40-pound box equivalent; in palletized tray-pack boxes, $3.24 per box; and in nonpalletized tray-pack boxes, $3.41 per box. Deep-cup pulpboard trays cost 4.2 cents per box more than shallow-cup pulpboard trays. In test shipments of Golden Delicious, Red Delicious, and Newtown apples to Sweden, total bruising (slight to serious) was 42 percent in the bin pallet boxes; 23 percent in nonpalletized tray-pack boxes; and 22 percent in palletized tray-pack boxes. Golden Delicious apples packed and shipped to England from Virginia in deep-cup trays sustained only 6 percent bruising compared with 11 percent for those packed and shipped in shallow-cup trays. No statistically significant differences in bruising of the apples resulted from shipping them on pallets in either type of tray.

Improved packaging of citrus exported to Europe.--Two export test shipments of Florida grapefruit packed in experimental 50- by 30-cm. and conventional size fiberboard boxes were made to Europe. One of the tests was made in a van container shipment and the other was in a break-bulk shipment. In the van container shipment the experimental and conventional boxes were both palletized and nonpalletized. In the break-bulk shipment they were hand stacked. In both test shipments about 20 percent of both types of boxes, either palletized or hand stacked, were crushed and creased.

Improved packaging of grapes exported to Europe.--Two test shipments of California grapes packed in 34-pound fiberboard boxes with sawdust instead of conventional 34-pound wood boxes with sawdust were made to London, England. The fiberboard boxes arrived in good condition and met with favorable trade reaction. In another test to London, grapes were packed in 22-pound wood boxes without sawdust. A slow release pad containing sulfur dioxide gas was placed in the top of the packed box before it was closed. The grapes arrived in good condition, indicating that it may be possible for the table grape industry to eliminate the use of sawdust for some export shipments.

Improved packaging of dried fruit for export.--In cooperation with the Forest Products Laboratory, Madison, Wisconsin, work to improve the shipping containers used to export dried fruit was continued. Random samples of fiberboard boxes were collected from manufacturers. Twelve types of dried fruit export boxes were tested. Compression tests have been completed and the data are now being analyzed. The effect of types of internal supports on top and bottom compression is to be tested. Detailed descriptions and specifications of containers used for export have been obtained and criteria for container testing were established.

Packaging and Handling of Ornamentals

Improved packaging of roses.--Six airfreight test shipments of cut roses were made from California to midwestern and eastern markets during the 1969-1970 winter months. The roses were packed, 500 per box, in conventional part-telescope fiberboard boxes, polystyrene foam boxes, and fiberboard "Vertical-Pak" boxes. Three shipments were made to "off-line" markets and three were direct flight shipments. The costs of packaging materials, packing labor, and transport were 3.4 cents per bloom for the conventional, part-telescope box, 3.0 cents per bloom for the polystyrene box, and 2.5 cents per bloom for the "Vertical-Pak" (shipped in an upright position instead of on the side) box. Lower packaging material costs, lower packing labor costs, and lower tare weight that resulted in lower transport costs were the principal factors accounting for the lower costs of marketing roses in the "Vertical-Pak" box. Each type of container had some damage. None of the flowers in the part-telescope fiberboard box were injured, whereas 0.1 percent was injured in the "Vertical-Pak" box and 1.0 percent was injured in the polystyrene foam box. None of the flowers sustained freezing injury. Wholesale flower receivers liked the part-telescope fiberboard box and the foam box better than the "Vertical-Pak" box for reuse in supplying flowers to retail florist shops.

Handling of bud-cut carnations.--A study was completed to determine the advantages and disadvantages of transporting and handling carnations cut in the bud stage instead of as open flowers. The research involved air shipment of over 40,000 carnation buds from California and Colorado growers to mid-western and eastern receivers. Approximately 99 percent of the buds were opened successfully at destination and sold commercially. Stripping excess leaves from the stems reduced the weight of the flowers about 13 percent which accounted for a saving in air transport cost of about $1.20 per 1,000 carnations. A total of 600 carnation buds was packed and shipped in a box designed to hold only 250 open carnations. If carnations were packed and transported by air in the bud instead of the open stage, the grower-shippers would realize savings of $2.30 and the receiver-retailers $4.29 for a total net saving of $6.59 per 1,000 carnations, over and above additional costs incurred for labor and refrigerated storage and room space to handle and open the buds to full bloom in retail stores. Results of the study showed the following additional advantages to be gained by transporting and handling carnations cut in the bud stage: (1) less breakage of flowers in the cutting and handling operations; (2) less spoilage--one retailer reported that his losses on carnations were reduced 18 percent; another reported a reduction of 22 percent; (3) since buds can be stored before opening, shipments can be made at less frequent intervals and in larger quantities, thereby reducing time for billing, telephoning orders, and other associated costs; and (4) ability to store buds in anticipation of peak demand periods. Growers, shippers, and receivers of carnations can realize savings in transport and handling costs of over $2.5 million per year if all of the carnations that are produced are shipped in the bud stage.

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Problems and Objectives

Farm and food products are loaded, transported, unloaded, and handled many times in the process of moving from farms to domestic and foreign consumers.

The costs of transport and related handling, estimated to be nearly $10 billion a year, are much higher than they need to be and they are constantly increasing. In addition, substantial losses occur through pilferage, inadequate environmental protection, poor loading or stowage methods, excessive or rough handling, delays in transit, and poor coordination of marketing, transport, and handling schedules. Such increases in costs due to transport deficiencies result in increased costs of the products to U.S. consumers and help to price American products out of the highly competitive and discriminating foreign markets.

Physical distribution research to apply new transport, handling, and engineering technology can lead to savings of $1.5 billion annually in marketing costs. This program can increase returns to farmers, provide better products at lower costs to the American consumer, and improve our competitive position in foreign markets.

Major present objectives of the research are to lower costs and improve transport and distributive efficiency by:

1. Developing new or improved environmental control systems for vehicles hauling perishable commodities.

2. Developing more versatile transport vehicles of lighter weight and greater load capacity, which can be more easily exchanged by different transport modes..

3. Developing loading and stowage methods to increase cargo space utilization in vehicles and reduce losses of farm and food products.

4. Reducing the number of handlings of products by means of van containers, palletization, and other unit load techniques.

5. Identifying problems concerning the physical distribution of U.S. products in foreign markets and conducting research to solve them.

Progress

Field Crops

Equipment to reduce transit losses of grain.--Previous exploratory research on grain losses in boxcars resulted in publication in April 1969 of ARS 52-25, "Relationships Between Grain Losses and Boxcar Defects." As a result of that report, the Illinois Central Railroad asked the Division to conduct further research into the problem of weight discrepancies in railroad shipments of grain. A tentative research plan was developed, but because of lack of funds, no research was actually initiated. It is understood that the Western Railroad Traffic Association is going to conduct a study of the same type as proposed by the Division.

Some exploratory work also was done to determine problems associated with overseas shipments of grain through Gulf ports to Europe.

Research on Michigan bean shipments to England.--Initial contacts were made with the Foreign Agricultural Service and the bean industry concerning possible plans for future research on overseas shipments of Michigan beans to England.

Fruits and Vegetables

Some redirection of this research to consider the total distribution system, as well as the individual steps of marketing, was undertaken this year. A project was begun to compare alternative physical distribution systems for fresh citrus fruits.

Alternative systems for packaging and distributing soft fruits.--Considerable progress was made on an analysis of alternative systems for packaging, handling, and distributing soft fruits such as pears, plums, and nectarines that are sold by retail stores in consumer packages. The data collected for previous research projects dealt with segments of the distribution system. Much of the data needed to compare alternative systems for Bartlett pears has been prepared partially through the analysis of secondary data sources and partially through synthesis of missing data.

A contract was given to Food Industries Research and Engineering to develop efficient shipping point prepackaging lines for plums and nectarines. Information on the costs of prepackaging plums and nectarines at shipping point will fill gaps in needed information. The utilization of loading space in railroad cars, piggyback trailers, and highway trailers by selected fresh fruit and vegetables shipped on 48- by 40-inch pallets was analyzed.

Citrus fruit unitization.--Comparative labor and equipment costs were studied for palletized loading and conventional manual loading methods for shipments of Florida citrus fruit. Use of expendable pallets and fiberboard slipsheets for loading the fruit into highway trailer vans showed significantly

lower handling costs than hand stacking of the boxes moved to the van by conveyor. Costs of equipment and labor for the unitized methods were about two-fifths of the cost of the forktruck-handstacking method, and about one-third of those for the conveyor-handstacking method. However, much of the savings in labor costs made possible by palletized loading are offset by the costs of material such as pallets and strapping. For palletized loading to be economically attractive for most shippers, the receiver who shares in the benefits of palletized loading also should share in the material costs of using the handling technique.

Seven stacking patterns for palletized units of Florida citrus fruit were evaluated, three for the 4/5-bushel fiberboard box, three for the bagmaster fiberboard box, and one for an experimental box for consumer bags. Tight-stacked and open-stacked, or air-flow patterns, were evaluated for each type of container. In-plant handling tests showed the tight-stack pattern to be more stable in loading and transport. Two of the tight-stack patterns tested gave significantly better payloads than the other patterns. Open-stack or air-flow patterns were found to have a slight advantage in allowing faster cooling of the fruit than the tight-stack pattern.

Research to determine the feasibility of shipping oranges and grapefruit in bulk in pallet containers of about 1,000-pounds capacity was continued during the year. Two experimental shipments were made from Florida and Texas producing areas to a prepackaging plant in Cincinnati, Ohio. Fruit bruising in the pallet container was within acceptable limits. The pallet container shipment from Texas required only 2.9 man-hours to load, while the same quantity of fruit shipped in 4/5-bushel corrugated fiberboard boxes required 3.4 man-hours. Unloading of the same quantity of fruit in pallet containers required from 0.25 to 0.30 man-hours compared to 3.4 man-hours for fruit shipped in 4/5-bushel corrugated fiberboard boxes.

To determine what types pallets would be best suited for palletized and unitized transport of citrus fruit, 16 types of expendable pallets were evaluated. Most of the pallets studied were too expensive, not strong enough, or too heavy to provide acceptable payloads in the highway trailer vans. Only one of those evaluated, the corrugated fiberboard slipsheet, made of 275-pound test strength board, was found to satisfy all criteria used as a basis for the evaluation. Disadvantages of the fiberboard slipsheets were (1) their tendency to tear under unfavorable handling conditions, and (2) the expensive special attachments required on forklift trucks to handle the slipsheets.

Unitizing and palletizing methods for potatoes.--Four methods of unitizing 10-pound plastic film and paper bags of potatoes into 4-, 5-, and 6-bag units automatically and semiautomatically were evaluated. The best method found for unitizing the 10-pound bags of potatoes was the "continuous bag" method. With this method the bags are formed and filled on the same machine and joined together as handling units of 4, 5, or 6 bags. There is a potential saving of 50 cents per hundredweight of potatoes using the "continuous bag" method as compared with the conventional method of filling individual bags and placing them in multiwall paper baler bags.

Loading and refrigeration techniques for fresh vegetables.--Inspection records on 300 shipments of vegetables by rail piggyback unloaded in New York and Chicago were studied to identify specific problem areas in transport of the products. The amounts of damage and deterioration and the condition of the loads and the transport equipment, as recorded in the inspection reports, were compared in an attempt to identify some of the more important causes of losses during transport. The results of this exploratory work will be used in planning additional research in this area.

A manuscript covering the results of research to identify and describe some of the more important problems in palletized transport of fresh vegetables was completed during the year.

Several exploratory test shipments were made with citrus and California long white potatoes in 180,000-pound-capacity bulk refrigerated hopper cars. The product arrived with approximately the same rate of bruising that occurred with pallet bins but with more bruising than for many conventional shipping containers. The system, however, offers opportunities for substantial savings in transport costs. Loading and unloading technology, however, must be improved. Such bulk shipments will probably be limited to larger processing or packaging plants.

Improving transport services, equipment, packaging, and handling of agricultural exports to Europe.--A new overseas research facility was established in Rotterdam, the Netherlands, in September 1969, to investigate problems associated with efficient marketing and distribution of U.S. agricultural products in Europe. Initial observations at major European markets have identified serious problems in transport services, packaging, handling, and equipment. These problems are materially affecting the marketing costs, arrival condition, and acceptability of our products in this foreign market. Many shipments required a 3-4 week transit period. Poor refrigeration and air circulation in van containers has caused losses in shipments of radishes, celery, and citrus. Reports have been made to individual exporters, recommending changes in handling and loading practices. Liaison is being maintained with major ocean carriers to help develop improved services and equipment with particular emphasis on refrigerated van containers for transporting fresh fruits and vegetables.

Conferences have been held in England, France, Germany, Belgium, and the Netherlands with importers, carriers, and U.S. agricultural attaches to investigate specific transportation and market distribution problems. Conferences were held with ocean carriers on deficiencies in performance of refrigerated van containers and recommendations were made to these ocean carriers to assist them in purchasing new properly designed equipment.

Observations and inspections were made on 10 experimental overseas shipping tests arriving in European markets. Reports were made to work unit leaders, including data on: (1) arrival condition, (2) performance of equipment, (3) adequacy of packaging, (4) handling techniques, (5) marketing costs, and

Research to reduce the costs of transporting products to overseas markets is vital to American agriculture.

(6) acceptance of the product in the market. Photographs were supplied, temperature data were collected from recording instruments, and the effects of adverse conditions evaluated. Observations also were made on approximately 50 commercial shipments of various U.S. products including grapes, radishes, celery, citrus, Chinese cabbage, lettuce, and onions. Receivers were interviewed to collect data on the trade reaction to U.S. products and to seek suggestions on desirable changes. Information also was obtained on the competitive position of U.S. products. The data and recommendations were relayed to exporters by work unit leaders. The use of improved practices for bracing and loading radishes has resulted in better product arrival and reduced losses. The introduction of a new experimental package for celery resulted in a request for commercial shipments by one importer.

Three experimental shipments of radishes in consumer-size polyethylene bags from Florida to Europe were made during the winter and early spring to evaluate load patterns that might allow better air circulation and improved product cooling in transit. Two other experimental shipments consisted of radishes packed in nylon open mesh bags and in wirebound crates. Planned shipping tests with a prototype waterproof ventilated hatch plug, designed to allow the use of outside air for product cooling while keeping out sea water, were cancelled after stationary tests showed that the plug restricted the entrance of air into the hatch openings. The hatch plug was redesigned and retested during the year. Results of the stationary tests indicate that the plug will allow entrance of sufficient outside air for adequate cooling of grapefruit and similar products during the winter months. In response to specific

requests from vegetable shippers, considerable time was spent in training loaders in the use of improved loading patterns. Further progress during the year was hampered by continued severe shortages of refrigerated container vans for overseas shipments and product shortages resulting from freezing damage and excess rain.

Animal Products and Poultry

Additional attention is being given to research in the animal products and poultry industries, both for domestic and foreign marketing problems.

Beef physical distribution systems research.--The A. T. Kearney Company, Inc., research contract publication on the feasibility of a physical distribution system model for the cattle and fresh beef industry has been widely distributed throughout the meat industry and has been discussed at many meetings during the past fiscal year. As a result, the Division Committee for Livestock and Meat Systems Research undertook a study of beef marketing and distribution from time of slaughter through the retail stores.

Under a cooperative agreement with Texas A&M University, an analysis is being made of beef marketing and distribution from the packinghouse to the wholesale distribution center. Shipping tests of carcass and boxed beef handling, packaging, and transport methods will be followed by experimentation on some new concepts, methods, materials, and equipment. Results to date have shown that primal cuts of beef which are vacuum packaged, boxed, and stored for 10 days yielded 3.7 percent additional product for retail sale, as compared to unpackaged primal beef cuts stored for the same period of time. Primal cuts stored in boxes after vacuum packaging lost 0.25 percent through shrinkage and 3.35 percent as trim from the surfaces of exposed lean meat, whereas primal cuts stored without protection lost 1.10 percent from shrinkage and 6.20 percent as trim from the exposed muscle surface.

Researchers at Kansas State University have cooperated in developing research plans and techniques for collecting the data required and have obtained industry cooperation to conduct their studies on chilling and retail operations. Data collection is presently underway to determine the costs of the many marketing functions conducted during distribution of the beef through the market channel. Both universities have received substantial additional financial and other kinds of support from industry firms and trade organizations. This has permitted the size and scope of the work to be expanded considerably beyond that expected from the Division's contribution. Coordination of the research at Texas A&M University and Kansas State University is being accomplished through a series of periodic meetings of researchers from both universities and a representative from the Division.

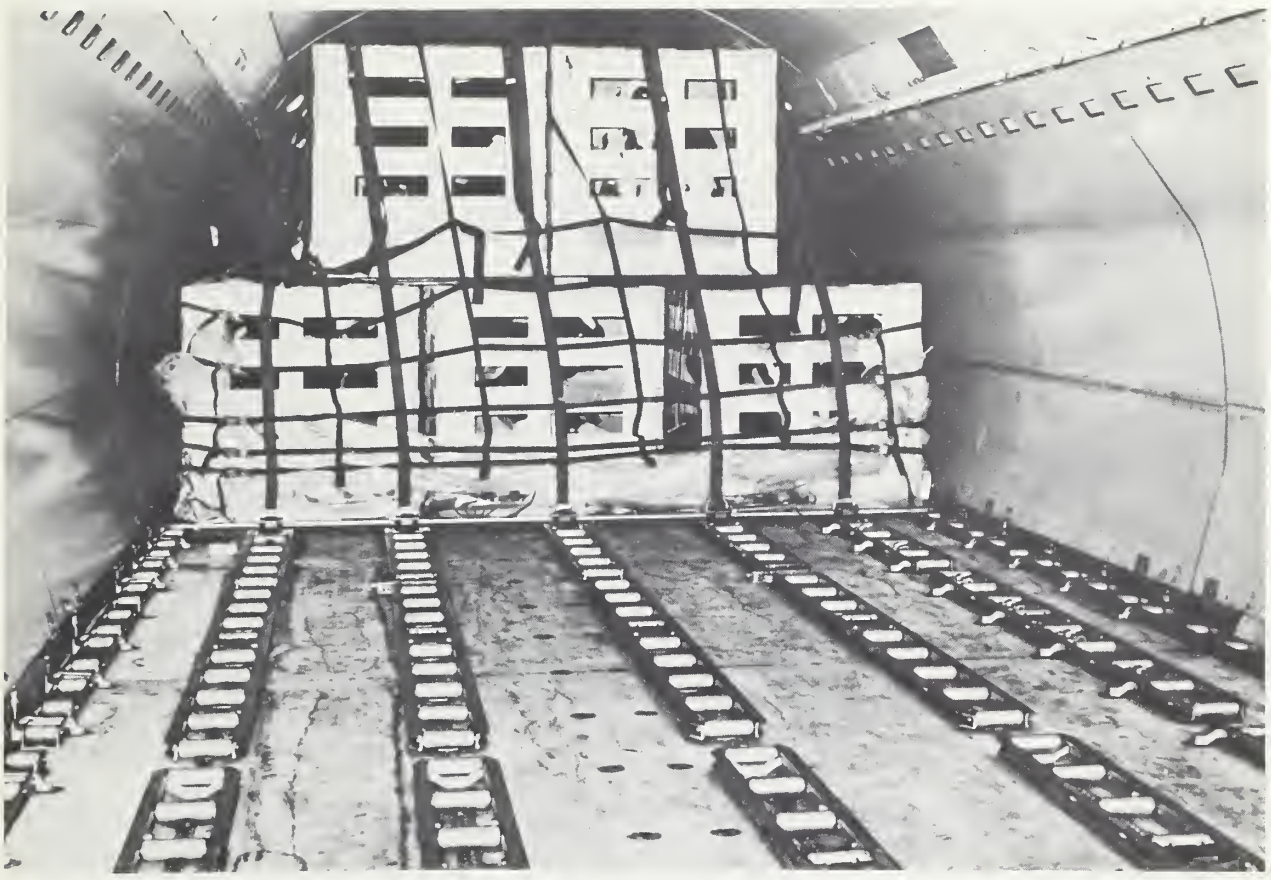
A second cooperative agreement with Kansas State University was negotiated this fiscal year to investigate the cost of chilling beef carcasses and to compare alternative systems of distributing beef from wholesale distribution centers to retail stores.

Improving transport of poultry to overseas markets.--The field work for this project was completed during the year with the gathering of cost data from container operators, the Maritime Administration, and other sources. A final report on this research is being prepared for publication. The results reported in this publication will supplement those in the interim report, ARS 52-28, "Transporting Packaged Frozen Poultry to European Markets in Van Containers and Break-Bulk Shipments," July 1968. Containerized transport and handling of frozen poultry to overseas markets reduced package and product damage and pilferage by about 70 percent, as compared with break-bulk shipments, the conventional method of ocean transport. Containerized transport also reduced handlings of individual packages of the product from about 12 to two, with significant savings in labor costs. In addition, the product in containerized shipments was maintained in a hard-frozen condition during the entire transit and handling period, with the temperatures never getting above 15° F. and being at 0° F. or below for about 95 percent of the transit period. In contrast, shipments by the conventional break-bulk method had product temperatures as high as 55° F., accompanied by partial thawing of the product, and transport temperatures mostly in the range of 15° to 25° F.

The product in the containerized shipments also was in better condition upon arrival at the overseas receiver's warehouse than the poultry shipped by the break-bulk method. This research also demonstrated that it was possible to use lighter, less expensive packaging with no strapping of individual packages for frozen poultry when the product is shipped in van containers. These reduced requirements for overseas shipments have resulted in substantial savings to poultry shippers in reduced material, labor, and handling costs. Division researchers also brought these findings to the attention of Consumer and Marketing Service and Foreign Agricultural Service people concerned with the shipping requirements for the Department's subsidized lots of poultry to overseas markets. The resulting revision of Consumer and Marketing Service specifications, which eliminated the requirements for strapping of individual boxes and reinspection of the van loads of poultry at the ports of shipment, has produced savings to the Department of from about $10,000 to $15,000 a year for each of the past 2 fiscal years on the cost of subsidizing export shipments of frozen poultry. When this research was begun about 4 years ago, no export shipments of frozen poultry were being containerized. Division researchers arranged for and made the first shipment. Since that time, use of this transport and handling technique has increased to the point where most of the frozen poultry shipped to overseas markets is containerized.

Improving transport of livestock overseas by air.--In an attempt to help American producers and exporters of breeding animals get their breeding stock to foreign receivers in better health and arrival condition, transport researchers of the Division, working with the Animal Health Division, developed and tested four types of pallet containers for transporting live animals by air. Included in the work are: (1) a plywood pallet pen for cattle, sheep, swine, and ponies, (2) an aluminum pallet crate for swine, cattle, and sheep, (3) a wirebound wooden crate for veal calves, and (4) the traditional wooden dowel crate for turkeys and pigs. All containers studied performed well.

Some are expendable and others are not. At least one type of container is low enough in cost and of sufficiently sturdy construction to be both expendable and reusable as the occasion demands. All containers are easy to clean, handle, and load and are readily accepted by the air carriers.



Breeder calves in pallet crates loaded
for air transport overseas

Cross Commodity Research

This research dealt largely with developing improved transportation or transport refrigeration equipment, in improving its utilization, and in standardization of sizes of equipment in use. The results are applicable to practically all agricultural commodities.

Handbook for truckers of perishable food products.--To help truckers, railroad piggyback, and van container operators do a more efficient job with present transport equipment, Agricultural Handbook 105, "Protecting Perishable

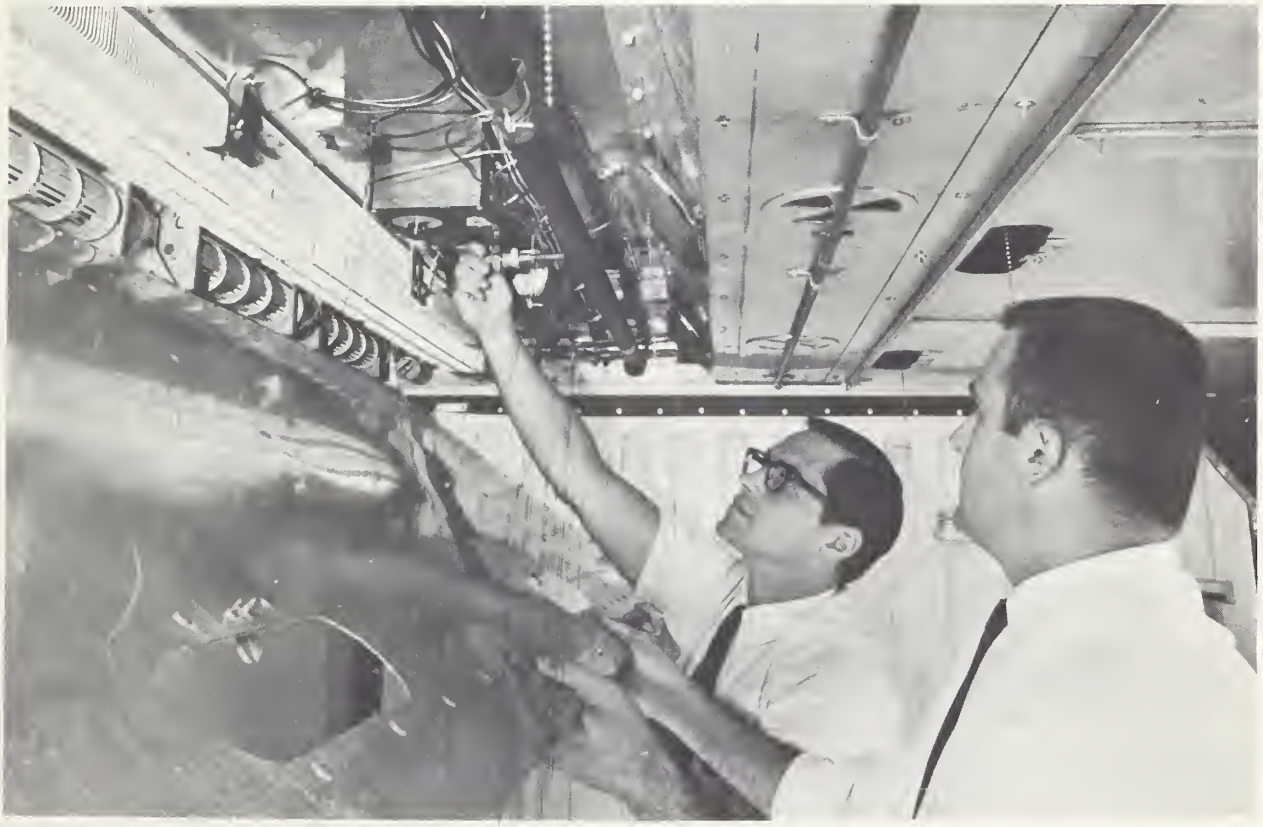
Foods During Transportation by Truck," one of the most popular publications of this Division, has been revised and updated. The publication, now being edited, is expected to be released in the next few months. The handbook will contain revised recommendations reflecting the results of about 12 years of research to improve the loading and handling of perishable products since publication of the first edition of the handbook. This publication describes the environmental requirements necessary for protection of the inherent quality of the perishables and tells how transport and refrigeration equipment should be used by the shipper, trucker, railroad, and container operator to meet them. Covered separately in the handbook are 70 perishable products, including frozen foods, meats, fruits and vegetables, and dairy products. The Division has on hand many hundreds of requests for the publication as soon as it is released. Also reflecting the interest in and demand for the handbook is the offer of the American Trucking Association to pay for printing the handbook to help speed its release since that association wants to obtain 5,000 copies to distribute to its member firms.

Comparison of costs of liquid nitrogen and mechanical refrigeration systems for truck trailers.--This research was done to provide the transportation and food distribution industry with information it can use in deciding which type of refrigeration system would give the lowest overall cost for a particular type of local delivery operation. Field work, in cooperation with a major chain store organization, has been completed. The data gathered have been analyzed and a manuscript, now in draft form, should be released for publication during the next few months. As far as can be determined by project personnel, this will be the first and only publication of its kind in the field. It is expected to help fill a vital information gap which affects transport industries' decisions on the investment of many millions of dollars annually in refrigerated transport equipment.

Development of international standards for refrigerated transport vehicles and van containers.--In an effort to help get the research results and expertise of the Division's transport and refrigeration researchers put to use in national and international transportation of farm and food products, work was continued during the year by having researchers take part in meetings to develop international standards and agreements for refrigerated transport equipment. This work included participation of researchers in the work of the Committee for Inland Transport of the Economic Commission for Europe. A manuscript,describing the test and certification procedures with which United States refrigerated transport equipment must comply to operate in Europe, is being prepared for publication. Meanwhile, other researchers continued to take an active part in the development of standards for van containers through the American National Standards Institute which also are proposed and frequently adopted as international standards by the worldwide International Standards Organization.

Multi-purpose van container.--Work on the development of the multi-purpose van container reached a milestone during the year with the completion of contract work on the van and the submission to the Division of the contractor's final report. The test van also was acquired from the contractor early

in the year for additional test work. A series of tests on the van to measure its airtightness, its thermal efficiency, and the capacity and power requirements of its refrigeration system were conducted at the Environmental Engineering Laboratories of the National Bureau of Standards at Gaithersburg, Maryland. The test van was subsequently transferred to the Division laboratory in Orlando, Florida, for some needed modifications and additional tests of its thermal efficiency. Interest of transportation firms, transport equipment manufacturers, and various related groups, both at home and abroad, in this developmental work remains at a high level. Several firms have contributed to the research and others have indicated their willingness to do so in later phases of the work.



Transportation researchers adjust the unique cooling coils and air circulator system in the multi-purpose van.

Development of improved cargo-securing equipment for piggyback and highway trailers and van containers.--To determine the extent and frequency of package and product damage associated with the lack or failure of load-securing equipment at the rear of loads in piggyback trailers, railroad inspection reports on fruit and vegetable shipments received in New York and Chicago were studied. Although the analysis of the data is not yet complete, preliminary results suggest that there is a high degree of correlation between the frequency and severity of transit damage and the lack or failure of load-securing equipment to hold the loads firmly in place. Two of the leading designers and

manufacturers of load-securing equipment have expressed a desire to work with the Division's transport researchers in developing and testing improved load-securing devices. A prototype of one such device has already been developed by one of the manufacturers and successful impact tests of it have already been observed by Division personnel. The design of the equipment is such that it will require only a minor adaptation to make it suitable for use in refrigerated trailer vans and containers.

Conversion system for transporting bulk liquid cargo in closed trailer vans.--The field work on this project has been completed and the manuscript covering research results was submitted to the Division by the Oregon Agricultural Experiment Station. This research resulted in the development of a conversion system suitable for transporting bulk liquid food products in large, collapsible, reusable rubber-fabric bag-tanks in closed trailer vans. To meet sanitation requirements, the system makes use of expendable, inexpensive plastic film liners for the bag tanks. A description of the system, the necessary components, the procedure for setting up and using it, and the appropriate formulas for determining when the use of such a system will be profitable in a particular transport operation have been developed. A large national food chain is now using the system in the Pacific Northwest to transport 4,500 gallons of whole milk to the firm's processing plant in closed trailer vans returning from rural areas after delivering groceries to supermarkets. The company is realizing savings of about 2.4 cents per trailer mile on a round trip of 866 miles, or about $350 per trip, and approximately $54,600 yearly. This conversion system also is suitable for transporting liquid sugar, honey, fruit juices, vinegar, and similar products.

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WHOLESALING, RETAILING, AND INSTITUTIONAL FOOD SERVICE

Problems and Objectives

On January 1, 1968, the Department discontinued the research on food wholesaling and retailing, and the personnel and remaining funds were reassigned to other Division programs. In January 1970, $100,000 of regular funds and $100,000 of ARS contingency research funds were appropriated by the Congress for the Division's use in restoring, in part, the wholesaling and retailing research work. Some of the money was used to restaff the area of research but most of it was used for five contracts and two cooperative agreements.

Major objectives of the research are to hold down or reduce rising food distribution costs and provide better food services to consumers by:

1. Increasing the efficiency of marketing firms through better operating methods, materials, equipment, layouts, and business practices.

2. Assistance and advice to smaller firms to permit them to compete and and thus maintain competition.

3. Developing food handling practices that will bring food to consumers cleaner, more healthful, and in better condition.

4. Using the results of these studies to provide inputs for more aggregative types of physical distribution systems research both on a vertical subsector and a functional basis.

Progress

Retail

Improved price-marking and checkout for grocery items.--The first operating optical scanner programmed to check out groceries for retail store operation was delivered to the Division for performance evaluation. In addition to performance evaluation, the scanner will be displayed to local industry and government groups to provide information on the developments and to create interest in this work.

A report entitled, "Feasibility of Mechanical Price-Marking of Groceries at the Central Warehouse" has been edited in the Information Division and forwarded for publication. This report shows that a grocery warehouse with a $40 million annual volume could save approximately 150 man-hours daily or $86,000 annually by pricing grocery items mechanically at the warehouse rather than by hand at the retail store. Additional research is needed on shipping split cases from the warehouse to the store, handling price changes, and retail store inventory management.

Development of operational standards for retail stores.--Operational computer models of a retail meat department and of a retail produce department have been completed. Twelve retail meat models have been tested against retail store weekly operating figures. Of the meat models tested, four were selected for best accuracy in predicting meat sales. Results were better than that experienced by traditional methods used in retail stores. Other operational data such as labor requirements and margin predictions were added to the model but accuracy of prediction is not yet ascertained. The produce model has not yet been tested against retail store data on a regular basis. A management information bulletin and a research report are being prepared on this research.

Layout guidelines for supermarkets.--Efficiency in supermarket operations is closely related to the effectiveness of the layout of the store. A cooperative agreement was concluded with the University of Missouri to determine and evaluate present methods, procedures, guidelines, or criteria used by store layout personnel; to select the best current plans used for layout; to develop improved guidelines; and to prepare a report summarizing this material.

Wholesale

Improved operational efficiency for complete line wholesale warehouses.--The contractor's report entitled "Forecasting Warehouse Produce Movement" was published. During the study, a computer model was developed for forecasting warehouse produce item movement. The model explained from 76 percent to 91 percent of the variance in weekly movements of the individual produce items in the 4 years of data included in the analysis. The model was successful in picking up the timing and direction of sharp changes in movement occurring in the data, although the magnitude of these changes was frequently understated and occasionally overstated.

Contractor studies also have been received on (1) the cost of servicing various size grocery orders; and (2) the effect of ceiling heights of 20 feet compared with 25 feet on costs of warehousing operations. Final reports on these subjects will be prepared during FY 1971.

Evaluation of improved methods for handling groceries between warehouses and retail store shelves.--In 1961, the Division published a report on handling groceries from the warehouse to retail store shelves. Since the report was issued, new handling methods have been developed which may be more efficient than those treated in that report. Several trade associations and wholesalers requested that the new handling methods be evaluated and that the 1961 publication be brought up to date. A contract was let for this purpose.

Costs and methods for supplying small stores from wholesale warehouses.--Many small stores in urban areas are finding it difficult to obtain their merchandise from suppliers at what they feel are competitive prices. Small lot deliveries, excessive handling, multiple stops with many trucks each day,

inadequate inventory control, and too much exposure of products to damage and pilferage make the costs unduly high in assembling orders and delivering products from wholesale warehouses to small stores. With the cooperation of the National-American Wholesale Grocers' Association and the National Association of Convenience Stores, a contract was let to determine and evaluate the possibilities of holding down these costs through the use of better equipment, better loading and unloading, improved routing and scheduling, containerized deliveries, consolidation of small lots, and other modifications of existing practices.

Institutional Food Service

Improved operational efficiency for food service outlets.--In the first phase of this project, the man-hour requirements, labor utilization, work methods, and layouts for two types of commercial table service restaurants were developed. The study showed that labor was effectively used only 74 percent of the time in the restaurants studied. The adoption of improved management practices could increase efficiency to 95 percent. Application of findings to the 4,000 restaurants in this size group would result in annual savings estimated at $1,200 million. Additional savings could be made by developing improved layouts, equipment, and work methods. The research was conducted through a cooperative agreement with the National Restaurant Association and the University of Delaware. A report documenting the research has been completed.

In the second phase of this project a contractor conducted a review of 918 published and unpublished reports pertaining to the food service industry. Of the 918 documents, 242 were judged to be research oriented and were summarized in abstract format. Concurrent with the literature review, interviews were conducted with industry leaders to determine their evaluation of research needs and problem areas and whether they knew of additional sources of research reports. Based on the interviews and literature reviews, the contractor made recommendations on needed research for the industry. This research has been completed and a report published.

Develop improved methods and operational standards for food service dishroom systems.--A dishroom system is defined as the process of transporting soiled and clean tableware within a restaurant or cafeteria and the machine washing of soiled tableware. A contract was let to determine the labor, equipment, and related costs for four specific dishwashing systems by the analysis of 12 restaurant and cafeteria operations; and to develop and test improved work methods, operating practices, equipment layout, and equipment design. The project was undertaken in cooperation with the National Restaurant Association.

The development of operational cost standards for restaurants offering repetitive-type menus to the general public.--Food service operators are currently determining gross processing costs through general accounting procedures. The cost to produce a specific item is generally determined by

multiplying the gross operating percentages for labor, material, and overhead by the sales price for a specific menu item. A much more exact method of cost allocation may be obtained by the development of operational standards which allocate the costs for labor, ingredients, and overhead to a specific menu item for determination of actual processing cost. In the past, the clerical labor required to administer a cost accounting system for specific menu items has been prohibitive, but the advent of electronic data processing and time sharing arrangements have made it feasible. A contract has been let to develop such a program and to prove its feasibility. The project is being undertaken in cooperation with the National Restaurant Association.

Develop a mathematical model to forecast weekly product volume in specialty-type restaurants.--Food service operators are currently predicting gross sales based on their historical knowledge of weather conditions, season of the year, and special events. These data are used to project the demand for specific menu items for purposes of purchasing food and scheduling employees. Discussions with industry leaders and a review of research-oriented literature have revealed that volume predictions based on the foregoing methods are inaccurate. A contract has been let to develop a predictive mathematical model in which the impact of such variable factors as advertising, weather, price, and automobile traffic will be evaluated. The development of this predictive model and the development of operational cost standards for specialty-type restaurants will enable operators to project resource requirements for labor, ingredients, and equipment requirements.

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